016.53
P578
1961
no.761

nce Abstracts

Section A

UNIVERSITY OF ILLINOIS
LIBRARY
JUN 21 1961
CHICAGO

Physics Abstracts

Published by
he Institution of
trical Engineers

Vol. 64 No. 761

May 1961

5113—6688

Physics Abstracts

Volume 64 MAY 1961 Number 761

CONTENTS

- MATHEMATICS *Page* 491
- ASTROPHYSICS 492
  - *Radioastronomy* 496
  - *Space research* 497
- PHYSICS 498
  - General 498
  - Gravitation. Relativity 498
  - Quantum theory 499
  - Statistical mechanics. Transfer processes 500
  - General mechanics 503
  - Mechanical measurements 504
  - Mechanics of fluids 504
  - Liquid state 505
  - Mechanics of gases 508
    - *Shock waves* 508
  - Gaseous state 508
  - Vacuum physics 509
  - Vibrations. Elastic waves 510
  - Acoustics 511
    - *Instruments and measurements* 512
    - *Noise. Architectural acoustics* —
  - Optics. Photometry 512
  - Geometrical and instrumental optics. Spectroscopy 512
  - Physical optics 513
  - Colorimetry. Photography 515
  - Heat. Radiation 515
  - Change of state 515
  - Thermodynamics 516
  - Low-temperature physics 516
    - *Liquid and solid helium* 516
    - *Superconductivity* 517
  - Electricity. Electrical measurements and circuits 518
  - Electrostatics. Dielectrics 519
  - Current electricity. Electrokinetics 519
  - Ionization 519
  - Electric discharges 520
  - Plasma 521
    - *Plasma oscillations* 526
  - Electron emission. Electron beams 527
  - Ion emission. Ion beams 528
  - Particle accelerators 528
  - X-ray tubes and techniques —
  - Magnetism 530
  - Electromagnetism. Magnetohydrodynamics 531
  - Electromagnetic waves and oscillations 536
    - *Radiofrequency spectroscopy techniques* 538
- NUCLEAR PHYSICS *Page* 539
  - Apparatus. Particle detectors 539
    - *Track visualization* 540
  - Nuclear field theory 540
  - Elementary particles 546
    - *Photons* 546
    - *X-rays* 547
    - *Neutrinos* —
    - *Electrons* 547
    - *Nucleons* 548
    - *Protons* 548
    - *Neutrons* 549
    - *Mesons* 550
    - *Hyperons* 554
    - *Deuterons* 555
    - *Tritons* 555
    - *Alpha-particles* 555
  - Cosmic rays 556
  - Nucleus 557
    - *Energy levels* 559
  - Nuclear decay. Radioactivity 561
  - Nuclear reactions 564
    - *Due to photons* 564
    - *Due to electrons* 566
    - *Due to nucleons* 566
    - *Due to protons* 566
    - *Due to neutrons* 567
    - *Due to mesons and hyperons* 568
    - *Due to deuterons* 568
    - *Due to alpha-particles* 569
    - *Due to other particles and nuclei* 569
    - *Nuclear fission* 570
    - *Thermonuclear reactions* 570
  - Nuclear power studies 570
- ATOMIC AND MOLECULAR PHYSICS 571
  - Atoms 571
    - *Isotopes* 573
    - *Mesic atoms* 573
  - Molecules 574
- SOLID-STATE PHYSICS *Page* 582
  - Lattice mechanics 582
    - *Thermal properties* 583
  - Electron states 584
  - Defect properties 586
    - *Diffusion* 586
    - *Colour centres* 587
    - *Radiation effects* 587
  - Electrical properties of solids 587
    - *Semiconductors* 588
    - *Semiconducting materials* 590
    - *Semiconductor devices* 591
    - *Photoconductivity* 592
    - *Thermoelectric properties* 593
    - *Dielectric properties* 593
  - Optical properties of solids 594
    - *Luminescence* 596
  - Magnetic properties of solids 599
    - *Magnetic resonances* 615
  - Mechanical properties of solids 620
  - Structure of solids 625
  - Crystallography 625
  - Crystal lattice structures 626
  - Alloys. Metallurgy 628
  - Other solid forms 631
    - *Surfaces. Films. Adsorption* 63
  - Microstructure examination 63
- PHYSICAL CHEMISTRY 63
  - Thermochemistry. Reactions 63
  - Electrochemistry 633
  - Photochemistry. Radiation chemistry 633
  - Dispersions. Colloids 634
  - Physical methods of chemical analysis 634
- GEOPHYSICS 635
  - Atmosphere 635
  - Upper atmosphere. Ionosphere 637
  - Geomagnetism 642
- BIOPHYSICS. PHYSIOLOGICAL PHYSICS 643
  - *Hearing. Speech* 644
  - *Vision* 644
- TECHNIQUE. MATERIALS 646

The monthly Author Index, List of Journals, Errata and Notes follow immediately after the last page of abstracts
For subscription rates, additional details, etc., see page iii of cover

---

RELATED SUBJECTS CONTAINED IN **Electrical Engineering Abstracts**

Electrical and magnetic measurements and instruments
Electronic relays and counters
Automatic control mechanisms
Applied electrochemistry
Lines and networks
Waveguides
Transistors
Photocells
Thermionic tubes
Cathode ray tubes
X-ray tubes
Oscillators. Pulse circuits
Amplifiers
Electroacoustic apparatus
Radiocommunication
Mechanical engineering
Illumination

THE INSTITUTION OF ELECTRICAL ENGINEERS, SAVOY PLACE, LONDON W.C.2 © 1961

Just Published

The Collected Works of
IRVING LANGMUIR

With contributions in Memoriam including a complete bibliography of his works

Chairman of the Honorary Editorial Advisory Board

GUY SUITS

VICE-PRESIDENT AND DIRECTOR OF RESEARCH, GENERAL ELECTRIC COMPANY

TITLES OF THE VOLUMES AND IN MEMORIAM CONTRIBUTORS

- *I Low Pressure Phenomena
  - **Sir Eric Rideal**
  - **P. W. Bridgman**
  - **S. Z. Roginsky**
- *II Heat Transfer—Incandescent Tungsten
  - **E. R. G. Eckert**
  - **Zay Jeffries**
- *III Thermionic Phenomena
  - **J. A. Becker**
- *IV Electrical Discharge
  - **J. D. Cobine**
- *V Plasma and Oscillations
  - **J. D. Cobine**
- *VI Structure of Matter
  - **David Harker**
- †VII Protein Structures
  - **Harry Sobotka**
- †VIII Properties of Matter
  - **Dean Henry Eyring**
- †IX Surface Phenomena
  - **N. K. Adam**
  - **W. A. Zisman**
- †X Atmospheric Phenomena
  - **V. J. Schaefer**
- †XI Cloud Nucleation
  - **Professor H. Byers**
- †XII Langmuir, the Man and the Scientist
  - **Biography by Albert Rosenfeld**

Part 1 of Volume XII entitled 'The Quintessence of Irving Langmuir' by Albert Rosenfeld, Scientific Editor of *Life*, is a brilliant biography of Langmuir.

* **Available immediately** † **To be published before the end of 1961**

The volumes are available separately, Volumes I–XI, £5 net each, and Volume XII, 60s. net. Volumes will be despatched and invoiced to customers as they are published.

£50 net per set of 12 volumes

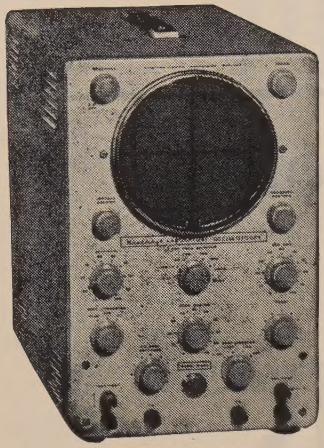
TAKE ADVANTAGE OF OUR 14 DAYS' APPROVAL PLAN

PERGAMON PRESS

OXFORD LONDON NEW YORK PARIS

Headington Hill Hall, Oxford 4 & 5 Fitzroy Square, London, W.1

122 East 55th Street, New York 22, N.Y.


Model O-12U
Oscilloscope

The kit-sets which give you the Best Possible Equipment at Absolutely Minimum Cost!

Heathkit
DAYSTROM

Examples are:—

5″ FLAT-SCREEN OSCILLOSCOPE, Model O-12U
Laboratory instrument at utility 'scope price. Exceptionally wide-range time-base (10 c/s to 500 Kc/s) "Y" frequency range 3 c/s to over 5 Mc/s, sensitivity 10 mV RMS/cm. Electronically stabilised. Output for Wobbulator, Voltage Calibrator (1 volt pk. to pk. source). Instantaneous shift, drift free. Automatic lock-in synch. Rise time 0.08μ secs or less. "Z" modn. facilities 2 gold-plated printed circuit boards and pre-cut cable wiring harness greatly facilitate assembly.............. **£36.10.0**

OSCILLOSCOPE TRACE DOUBLER, ELECTRONIC SWITCH, Model S-3U
This extremely useful, low priced device will extend the use of your single-beam oscilloscope for duties otherwise only in the province of the double-beam tube. In short, at a nominal cost, the Heathkit model S-3U will give you the advantages of a double (or other multiple) beam 'scope, while retaining all the advantages of your present single-beam instrument. Hitherto an electronic switch of this nature, permitting the simultaneous observation of two signals on the screen of a single-beam C.R.T. oscilloscope, has cost nearly as much as the 'scope itself. **£10.15.6**

PORTABLE 2¾″ SERVICE 'SCOPE, Model OS-1
The OS-1 uses a 2¾″ cathode ray tube and is a compact portable oscilloscope ideal for servicing and general laboratory work. Y amplifier sensitively 10m V/cm; response ± 3 dB 10 c/s-2.5 Mc/s. Time base 15 c/s–150Kc/s. Features include Int. Ext. and 50 c/s sync; Sine sweep; time base output for wobbulator; X amplifier socket; 1, 10 and 50 volt calibrator. Uses printed circuit board for consistency and ease of assembly Case 7⅞″ × 4$\frac{11}{16}$″ × 12½″ long. Weight only 10½ lb. **£19.10.0**

VALVE VOLTMETER, Model V-7A. Because of the accuracy, reliability and sheer value of the Model V-7A it is outselling all other VVM's. The precision and quality of its first-class components cannot be duplicated elsewhere at this price. Indication is by a large 4½″ 200 μA meter clearly calibrated for all ranges. The voltage divider networks use 1% precision resistors. A gold-plated printed-circuit board simplifies the assembly, saves time and eliminates the possibility of wiring errors. It also ensures duplication of laboratory performance. This multi-function VVM measures A.C. Volts (RMS and pk. to pk.), D.C. Volts and Resistance. The 7, A.C. (RMS) and D.C. ranges are 1.5, 5, 15, 50, 150, 500 and 1500. The 7, A.C. pk. to pk. Voltage ranges are 4, 14, 40, 140, 400, 1400 and 4000. D.C. input impedance is 11 MΩ. Seven Ohm-meter ranges have multiplying factors of X1, X10, X100, X1000, X10 K, X100 K and X1 MΩ. Centre-scale resistance readings are 10, 100, 1000, 10 K Ohms, 1 MΩ and 10 MΩ. A centre-zero dB scale is provided also for measuring audio amplifier performance. Test leads, prods and battery are included in the kit. **£13.0.0**
PROBES: R.F. **£1.9.6**, H.V. (30 kV d.c.) **£2.15.6.**

Audio Signal Generator, AG-9U. A high class audio generator covering a frequency range of 10 c/s to 100 Kc/s. Distortion is less than 0.1% between 20 c/s and 20 Kc/s. Frequency is selected by the two decade switches times the multiplier. Output constant over the whole frequency range approx. ± 1 dB and is variable from 3 mV f.s.d. to 10 V f.s.d. Output monitored by a 4½″ panel mounted 200 μA., m.c. meter **£19.19.6**

Direct Reading Capacitance Meter, CM-1U. Measures 100 μ μF full scale to .1 μF full scale with complete accuracy. 1% external standards provided for each of the four ranges **£14.15.0**

Multimeter, MM-1U. Measures wide range of voltage, current, resistance and dB in over 20 ranges. Sensitivity 20,000 ohms/volt D.C. and 5000 ohms/volt A.C. 0–1·5, 1500 volts A.C. and D.C. 0–150 μA, 15 A D.C. Resistance 0.2 ohms to 20 megohms. 4½″ meter, 50 μA f.s.d. **£11.18.6**

Audio-Millivoltmeter, AV-3U. An A.C. valve millivoltmeter having 10 ranges for measurement from 10 mV f.s.d. to 300 V f.s.d. Frequency response 10 c/s to 400 Kc/s ± 1 dB. Input resistance not less than 1 megohm. 4½″ meter with 200 μA movement **£13.18.6**

Audio Wattmeter, AW-1U. Power range 5 mW—50 W f.s.d. Frequency response 10 c/s to 250 Kc/s ± 1 dB. Internal load resistors 3, 8, 15 and 600 ohms ± 1% non-inductive and switch selected. Power ratings 25 watts continuous, 50 watts intermittent. 4½″ meter with 200 μA movement **£14.14.0**

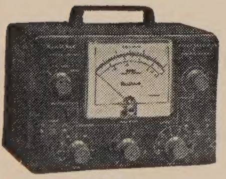
Power Supply Unit, MGP-1. Provides 3 D.C. outlets 250-300 V up to 90 mA., 170-220 V up to 30 mA, 150-200 V up to 10 mA and 6.3 V at 2.5 A A.C. **£4.16.6**

Decade Capacitance Box, DC-1. Precision 1% silver mica capacitors are used and switches are of the ceramic wafer type to ensure minimum loss. Three decades switches are used and cover a range of 100 pF to 0.111 μF in increments of 100 pF. **£6.5.6**

Resistance-Capacitance Bridge, C-3U. Resistance Capacitance Bridge measures capacitance up to 1000 μF and resistance up to 5 megohms. Also indicates leakage and provides a range of D.C. test voltages **£8.6.6**

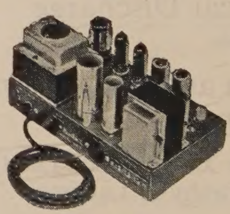
Amplifier MA-12. A 10-12 watt high fidelity amplifier having extremely low distortion and wide frequency range. Generous auxiliary power supply provided .. **£10.19.6**

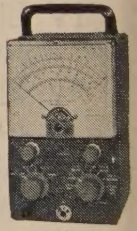
R.F. Signal Generator, RF-1U. Provides an accurate source of RF up to 100 Mc/s on fundamentals and 200 Mc/s on harmonics. Up to 100 mV output on all bands **£11.18.0**


AG-9U

C-3U

S-3U


MA-12


V-7A

***ALL AMERICAN KITS ARE NOW AVAILABLE** (including Analogue Computers from £90 to £490)*

Here are a few other examples:—

"Professional" 5″ DC Oscilloscope, Model OP-1. Featuring a calibrated driven sweep with built-in triggering circuits, D.C. coupled vertical amplifier and a 5ADP2 flat-face CRT, the OP-1 offers professional performance at big savings **£101.5.6**

"General Research" 5″ DC Oscilloscope, Model OR-1. An excellent read-out indicator in computer applications, as well as a versatile general service 'scope. Features identical D.C. coupled vertical amplifiers, 5ADP2 flat-face C.R.T, and transformer operated silicon diode power supply **£65.13.6**

"Q" Meter, Model QM-1. Measures inductance from 1 microhenry to 10 millihenrys, "Q" on a scale calibrated up to 250 full scale, with multipliers of 1 or 2, and capacitance from 40 mmf to 450 mmf, ± 3 mmf vernier. Test coil for calibration and easy-to-follow instructions furnished **£28.10.0**

Harmonic Distortion Meter, Model HD-1. Measures harmonic distortion in amplifiers at frequencies between 20 and 20,000 CPS. Distortion ranges are 0-1, 3, 10, 30 and 100% full scale. Full scale voltage ranges are 0-1, 3, 10 and 30 V Features high input impedance and 1% precision resistors. Ideal for use with Heathkit model AG-9U Audio Generator **£25.2.0**

Impedance Bridge, Model IB-2A. Wheatstone bridge, capacity comparison bridge, Maxwell bridge and a Hay bridge in one compact unit. Measures resistance from 0.1 ohm to 10 megohms, capacitance from 100 mmf to 100 mfd, inductance from 0.1 mh to 100 h, dissipation factor (D) from 0.002 to 1 and storage factor (Q) from 0.1 to 1000. Built-in power supply, 1000 cycle generator and valve detector. Shpg. **£30.16.0**

We also recommend to you the American Heathkit **Transistorised Intercom Units** for use in the factory, office or home. The system consists of a master unit and up to 5 remote stations. .. .. XI-1 Master Station **£14.3.0**; XIR-1 Remote Station **£4.5.0**

N.B. Complete Catalogue of British HEATHKIT range and full details of any models gladly sent on request

DAYSTROM LTD

DEPT. SA5
GLOUCESTER

Type SJ

Silicon Junction Rectifiers

Now with these new

Improved design features

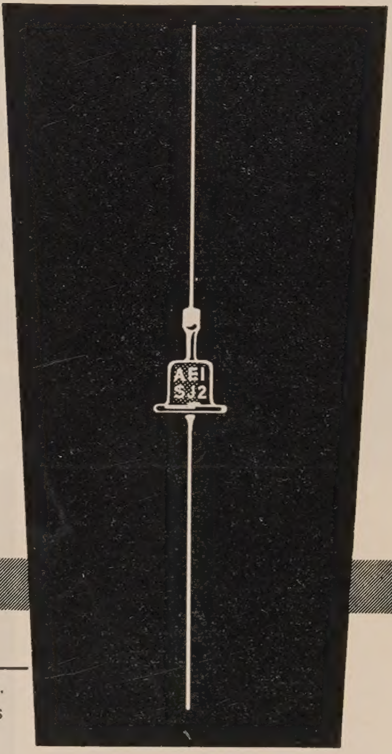
Special protective, non-conductive silicone-enamelled finish over silver plating. Minimizes the possibility of flash-over in dirty environments. (Cooling fin efficiency is unaffected.)

Reduced flange diameter. Wire-ended Form 'F' units 0.4 in. max. Saves space in electronic equipment.

Type SJ Rectifiers are:

RESISTANT TO SHOCK AND VIBRATION

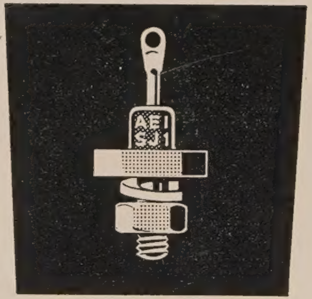
COMPLETELY RELIABLE · FULLY 'TROPICALISED'



Ratings

TYPE	P.I.V. Volts	TYPE	P.I.V. Volts	TYPE	P.I.V. Volts	TYPE	P.I.V. Volts
MAXIMUM CURRENT AT 25°C							
0.7 amp.		1.0 amp.		1.5 amp.*		2.3 amp.*	
SJ051F	50	SJ052F	50	SJ051A	50	SJ052A	50
SJ101F	100	SJ102F	100	SJ101A	100	SJ102A	100
SJ201F	200	SJ202F	200	SJ201A	200	SJ202A	200
SJ301F	300	SJ302F	300	SJ301A	300	SJ302A	300
SJ401F	400	SJ402F	400	SJ401A	400	SJ402A	400
SJ501F	500			SJ501A	500		
SJ601F	600			SJ601A	600		
MAXIMUM JUNCTION TEMPERATURE							
120°C		200°C		120°C		200°C	

* When mounted on suitable cooling fin



APPLICATIONS

- Rectification
- Control
- Magnetic amplifiers
- Brushless alternators
- Power packs
- Blocking duties

Please write for full details to your nearest AEI District Office, or to

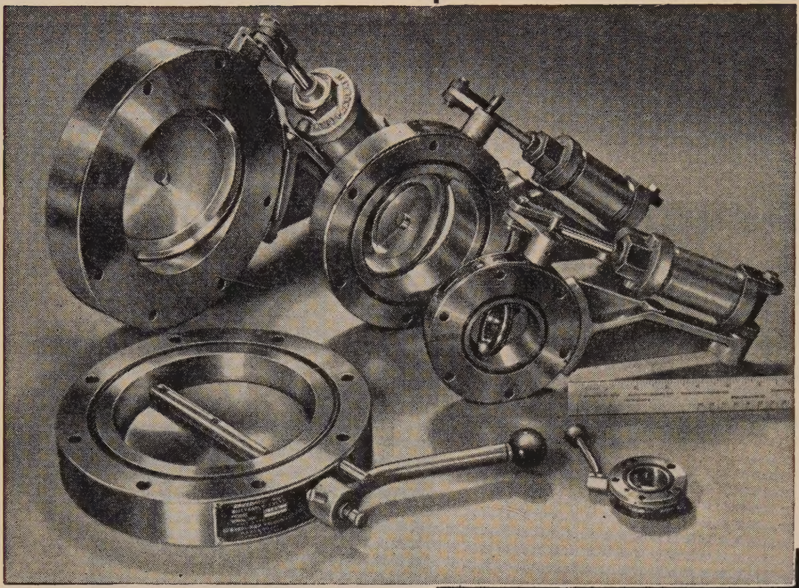
AEI

Associated Electrical Industries Limited

Electronic Apparatus Division

VALVE AND SEMICONDUCTOR SALES
LINCOLN, ENGLAND

AS628



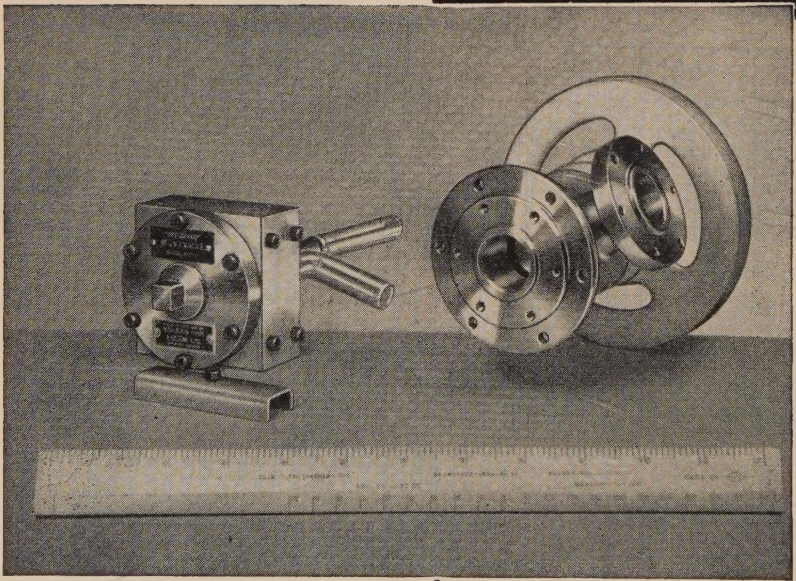
REALLY COMPACT HIGH-CONDUCTANCE ISOLATION VALVES

Capable of resisting pressure differentials in either direction the series QSB Butterfly valves are made in stainless steel and are available in manually or pneumatically operated versions, the latter being specially designed for remote or automatic control.

The QSB range includes valves of 1 in., 2 in., 4 in., 6 in., nominal bore. Another version is the BQSB1 which is a variant in brass with 1 in. Edwards vacuum union connections.

"SPEEDIVAC"

HIGH VACUUM VALVES



METAL CLOSURE BAKEABLE VALVES

The "Speedivac" series of metal closure valves are specially designed for those applications which require a vacuum in the region of 10^{-10} torr and which necessitate the use of bakeable all-metal systems. These valves may be baked to a temperature of about 450° C for degassing.

Model MCV1: Annular port area of 0·1 in.^{2} when open and a closed molecular conductance for air of about 10^{-10} to 10^{-11} 1/sec.

Model MVC4: Annular port area of 1 in.^{2} when open and a closed molecular conductance for air of about 10^{-8} to 10^{-9} 1/sec.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY Crawley 1500 | SUSSEX | ENGLAND

PHYSICS ABSTRACTS

olume 64 MAY 1961 Number 761

MATHEMATICS

5113 AN INTRODUCTION TO THE LAPLACE TRANSFORMATION WITH ENGINEERING APPLICATIONS.
C.Jaeger.
d ed. London: Methuen and Company; New York: John Wiley and
ns (1961) viii + 156 pp.

This is second edition of a book which appeared originally in
)49. It is intended to cater for the needs of physicists and engin-
rs who encounter transient problems and who wish for an altern-
ive method of solution to that offered by Heaviside's operational
lculus. In the original edition, theory was kept to a minimum and
e book was largely a collection of worked examples illustrating
ethods of solution. Due to the importance in modern circuit theory
immittance functions, a new chapter has been added on the theory
functions of a complex variable and the way in which it is applied
conjunction with the inversion theorem. An introduction to the
quist criterion for stability is included.

5114 CALCULATION OF THE MEAN VALUES OF FUNCTIONS OF DISTANCE FROM A POINT OVER A SURFACE OR VOLUME. G.A.Grinberg.
. tekh. Fiz. (USSR), Vol. 31, No. 1, 3-12 (Jan., 1961). In Russian.

The evaluation of integrals of the form

$$\int_{(f)} F(R)\,.\,df$$

discussed, where (f) is a plane or solid figure, and F(R) is an
plicit function of R, the Euclidean distance from a fixed point O
the element df of (f). The function F(R) can be taken, for example,
be proportional to R^{-1}, for calculation of potential, or to R^{-3},
r calculation of solid angle. Special cases considered include
e calculation of potential at a point O outside the plane of a uniform
stribution of electrical charge over a polygon, a circle or an
lipse. Solid figures are considered rather more briefly; potential
tside a charged polyhedron is considered as an illustrative
ample. [English translation in: Soviet Physics—Technical
ysics (USA)]. N.L.Johnson

ANALOGUE METHOD OF SOLVING POISSON'S EQUATION IN TWO DIMENSIONS. See Abstr. 5264

5115 LIMITING SOLUTIONS OF A NON-LINEAR EQUATION OF PARABOLIC TYPE.
.M.Zaidel' and K.A.Semendyaev.
okl. Akad. Nauk SSSR, Vol. 133, No. 2, 311-14 (July 11, 1960).
Russian.

For abstract, see Abstr. 14364 of 1960. [English translation
: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 705-8 (Jan.-Feb.,
)61)].

5116 METHOD FOR THE CONSISTENT TRANSFORMATION OF PHYSICAL EQUATIONS INTO NON-DIMENSIONALLY ARAMETRIC FORM. J.C.Amson.
rit. J. appl. Phys., Vol. 12, No. 4, 180-3 (April, 1961).

Necessary and sufficient conditions for the existence of a
mplifying transformation of a set of physical equations are given,
ereby the physical variables involved become a less numerous set of dimensionless parameters. The proof provides a method for performing this transformation and for deciding whether it is unique, and this method is described. Whilst such a transformation is always possible for a single physical equation whose form is algebraic, its existence and description is not always apparent when more than one such algebraic equation is affected and the transformation is required to apply consistently to each, or when the equations are not algebraic. The method described is applicable not merely to sets of general equations, but to any collection of power-products of physical variables whose consistent transformation is desired.

5117 CONFORMAL TRANSFORMATIONS BY ANALOGUE COMPUTER. E.J.Joss and D.S.Ross.
Brit. J. appl. Phys. Vol. 12, No. 4, 178-9 (April, 1961).

This paper describes the use of an analogue computer to generate certain conformal transformations of the circle, these being of use in the analysis of stress patterns in the neighbourhood of holes of various shapes. The relationship between the form of transformation and the shape produced is also discussed.

5118 A SUCCESSFUL VERSION OF THE BEEVERS—MACEWAN FOURIER SYNTHESIZER USING DEKATRON COUNTERS. J.W.Jeffery.
J. sci. Instrum. (GB), Vol. 38, No. 4, 119-25 (April, 1961).

A modified version of the Beevers—Macewan machine (Abstr. 8 of 1943) is described. The machine calculates a Fourier synthesis on exactly the same principle as the Beevers and Lipson strips. A switch selects cos or sin; one set of push buttons selects the wave number (0-99) and a second set selects the amplitude (1-100). On pushing the + or − button the machine adds in the numbers on the corresponding strip to 16 counters simultaneously. When all the terms have been put in, the result for 0-15/60 of the period, in steps of 1/60, is registered on the counters, negative numbers being given as complements. The main difficulty in previous designs, which had not been surmounted, was to obtain reliable counters which would work backwards as well as forwards and could be quickly zeroed. This has now been accomplished by utilizing dekatron counters and running the Post Office selector switch at 20 steps per second, the maximum for reliable single stepping operation. A term of amplitude 100 thus requires 5 seconds to put in, but a term of amplitude 10 takes under 1 second because the function-generating uniselector finishes the rotation from position 11 onwards at its normal speed of 299 positions per second.

5119 TRANSISTORIZED APPARATUS FOR ACCUMULATION AND BINARY—DECIMAL CONVERSION.
D.Brini, A.Gandolfi and G.L.Tabellini.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 46-54 (July, 1960).

The apparatus described is capable of adding binary numbers and of converting the sum into decimal form. The fundamental unit is a decade element having four inputs corresponding to the numbers 1, 2, 4, 8 and output Z corresponding to the carry. The number which is stored in the decade element can be read directly on an instrument.

ASTROPHYSICS

5120 ABSTRACTS OF PAPERS PRESENTED AT THE 107th MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY, DECEMBER 29-31, 1960 AT THE HOTEL ROOSEVELT, NEW YORK CITY.

Astron. J. (USA), Vol. 66, No. 2, 37-59 (March, 1961).

5121 PROBLEMS IN MERIDIAN ASTRONOMY.

G.van Herk and A.J.J.van Woerkom.

Astron. J. (USA), Vol. 66, No. 2, 87-95 (March, 1961).

The necessity for research in meridian astronomy is stressed, and several possibilities to increase the accuracy are proposed. It is emphasized that a meridian circle is a laboratory precision instrument that is used under trying circumstances. The shortcomings of modern meridian work are traced to several sources. Not much improvement in the final results has been made during the past century judged by differences in modern catalogues. Research in different directions is suggested to speed up the acquisition of improved proper motions.

5122 DESCRIPTION OF A MIRROR SYSTEM WITH 120° OF FIELD, FOR THE PHOTOGRAPHIC PHOTOMETRY OF EXTENDED CELESTIAL SOURCES.

R.Dumont.

Rev. Opt. (France), Vol. 38, No. 8, 395-400 (Aug., 1959). In French.

The image formed by a concave sperical mirror is photographed by a conventional short focus camera. There is only a very small change of illumination over the entire field so that photographic photometry is possible. Practical details are given, together with typical results.

R.W.Fish

5123 ELECTRON IMAGE AMPLIFIER FOR APPLICATIONS IN ASTRONOMY.

G.Lewin.

Rev. sci. Instrum. (USA), Vol. 32, No. 2, 206-7 (Feb., 1961).

A Lallemand image amplifier is provided with a differential thermal-expansion valve between the photographic and photoelectronic sections, making possible the use and exchange of photographic plates without impairing the photo-emissive surface. With the use of a very weak ion pump, it is estimated that the photoemissive surface will not deteriorate for several months.

B.Meltzer

5124 THE [RIVAL] CLAIMS OF SOME IMAGE STORAGE METHODS IN ASTRONOMICAL MEASURING TECHNIQUES.

H.Siedentopf.

SB Heidelberg. Akad. Wiss. (math. nat. Kl.) (Germany), 1959, No. 5, 4-16. In German.

"Image convertors and storage tubes" meeting, Heidelberg, 1958 (see Abstr. 3004 of 1961). A comparative study of modern photoelectric (photomultipliers and image-storage devices) and photographic methods used in astronomical research for detecting and measuring the very low radiation fluxes of great importance in current astrophysical and cosmical problems. Operational data for the two methods are tabulated; and a discussion is included of the comparative cost of apparatus needed to provide the same amount of information on each of the two systems.

D.R.Barber

5125 SPECIAL STORAGE TUBES FOR USE IN ASTRONOMY.

R.Theile.

SB Heidelberg Akad. Wiss. (math. nat. Kl.) (Germany), 1959, No. 5, 50-3. In German.

"Image convertors and storage tubes" meeting, Heidelberg, 1958 (see Abstr. 3004 of 1961). Describes three types working on the storage principle and suited for astronomical work. The first uses a storage grid mounted near the fluorescent screen and an auxiliary gun to render the stored image visible on the screen. The design of the other two tubes follows suggestions made by McGee and makes use of mechanical movement of the storage plate.

A.E.I. Research Laboratory

5126 SHORT REPORT ON AMERICAN, ENGLISH AND FRENCH WORK ON THE USE OF IMAGE STORAGE TUBES AND IMAGE INTENSIFIERS IN ASTRONOMICAL OBSERVATIONS.

J.Dachs.

SB Heidelberg Akad. Wiss. (math. nat. Kl.) (Germany), 1959, No. 5, 54-8. In German.

"Image convertors and storage tubes" meeting, Heidelberg, 1958 (See Abstr. 3004 of 1961). Briefly reviews the methods that are in use for intensifying the optical image in an astronomical telescope. These include the sealed-off photo-tube, devised by Lallemand, which contains a photographic plate and has a working life of half an hour, and the demountable version by Hiltner. Other tubes rely on a series of screens coated on one side with a phosphor which is bombarded by electrons and on the other with a photo-sensitive laye Finally the application of conventional storage tubes to small telescopes is discussed.

A.E.I. Research Laboratory

5127 THE ABILITY OF THE 200-INCH TELESCOPE TO DISCRIMINATE BETWEEN SELECTED WORLD MODELS.

A.Sandage.

Astrophys. J. (USA), Vol. 133, No. 2, 355-92 (March, 1961).

The present paper reviews several tests which can be performed to decide between world models, discussed in terms of the capabilities of the 200-inch Hale telescope. The tests include (1) th deviation from linearity of the red-shift—magnitude relation; (2) the galaxy-count—magnitude relation; (3) the angular-diameter—red-shift relation treated for both metric and isophotal diameters; and (4) the time scale. Selected exploding models of the Friedman type and the steady-state model are considered. The object of the tests to determine observationally the deceleration parameter q_0. Once q_0 is known, the world model follows from the equations given. It appears possible to find q_0 from the magnitude—red-shift relatio At a red shift $(\Delta\lambda/\lambda_0)$ of $z = 0.5$, a difference of 0.9 mag. exists in the $[m, z]$ relation between a closed, elliptical universe with $q_0 = +1$ and the steady-state model with $q_0 = -1$. Such a difference can possibly be detected if the aperture effect for the measurement of intensities and if the Scott effect of observational selection can be allowe for. The value of q_0 is presently estimated to lie between 0 and +3. The most probable value is $q_0 = 1 \pm \frac{1}{2}$. The predictions of steady-state cosmology would appear to be inconsistent with present infor tion. The N(m) relation for galaxy counts is derived for all models considered. Galaxy counts are insensitive to the model. At the lim of the 200-inch, an observational error of only $\Delta m_R = 0.28$ mag. ca change the counts from indicating a closed universe with $q_0 = +1$ to an open, empty model with $q_0 = 0$. There seems to be no hope of fin ing q_0 from the N(m) counts because the predicted differences between the models are too small compared with the known fluctuatio of the distribution. The angular diameters of clusters of galaxies and of galaxies themselves are discussed. The angular diameter su tended by a linear distance y is shown to change with z in a differe way than the isophotal diameters. Both types of diameters are considered, and a test for q_0 seems to be possible with the 200-inch, b the test will be difficult and perhaps marginal. Equations for the time t_0 since the beginning of the expansion are derived. It is show that t_0 is a function of the Hubble parameter H_0 and q_0 alone for exploding models with $\Lambda = 0$. The present value of H_0 and the age of the oldest stars are shown to be incompatible. If $q_0 = +1$, then $t_0 = 0.571\ H_0^{-1} = 7.42 \times 10^9$ years (assuming $H_0 = 75$ km/sec 10^6 pc). However, the age of the oldest stars in the Galaxy is computed to b greater than 15×10^9 years if the most recent stellar models of Hazelgrove and Hoyle are used. These values are too uncertain to claim that exploding models with $\Lambda = 0$ are incorrect, but the data, as given, would so require. It is shown in the final section that exploding models of the Lemaitre—Eddington type approach asympto ically $q_0 = -1$ and are therefore like the steady-state model. In the limit both models predict the same $[m, z]$ and $[\theta, z]$ relations. Consequently, tests of the type considered cannot decide between these particular models. Appeal to the time independence of the steady-state model must then be made for a test. An appendix gives the explicit equations for N(m) for various q_0 values.

5128 ON ANTIMATTER AND COSMOLOGY.

C.J.Kevane.

Science (USA), Vol. 133, 580-1 (Feb. 24, 1961).

A cosmological model based on a gravitational plasma of matter and antimatter is discussed. The antigravitational interaction of matter and antimatter leads to segregation and an expansion of the plasma universe. The expansion time scale is controlled by the aggregation time scale.

IONIZATION OF A STATIC INTERPLANETARY GAS AND
XPECTED EMISSION LINES FROM THIS GAS.
ee Abstr. 5129

5129 IONIZATION OF A STATIC INTERPLANETARY GAS AND EXPECTED EMISSION LINES FROM THIS GAS.

I.N.Rundle.

lanet. Space Sci. (GB), Vol. 2, No. 2-3, 86-98 (April, 1960).

The degree of ionization of hydrogen and helium in a static nterplanetary gas is calculated and the expected intensities of the nore intense helium emission lines in the visible and infrared egions are given as a function of electron density and kinetic emperature. A zodiacal light spectrum recently obtained places an pper limit on the static electron density for given kinetic temperaures. Future high resolution observations of wavelengths 5876 or 0 829 A could give useful upper limits on the static electron denities for kinetic temperatures below 10^5°K. Comments are made n the observations of H_α.

5130 BODE'S LAW AND THE SOLAR SYSTEM.

M.M.Woolfson.

Nature (GB), Vol. 188, 1175-6 (Dec. 31, 1960).

Making the tacit assumption that any correct explanation of the rigin of the solar system must account for Bode's law, it is shown hat the model proposed recently (Abstr. 14393 of 1960) leads to disance parameters for the major planets that are in good agreement ith observation. The following distinctive features emerge from the nalysis: (1) mercury does not fit into the general system, its large ccentricity indicating a different epoch of origin of its present rbital motion; (2) two additional planets are predicted between the rbits of Mars and Jupiter. These were most probably destroyed by irect collision, leaving as debris the present asteroid belt; (3) conrary to the prediction of Bode's law, Neptune is a natural member of he solar system. Since its inception (1960), the time-scale associted with the model has been increased by a factor of ~10^5 without nvalidating any basic ideas. D.R.Barber

5131 THE DISTRIBUTION OF HYDROGEN IN THE TELLURIC HYDROGEN CORONA. F.S.Johnson.

strophys. J. (USA), Vol. 133, No. 2, 701-5 (March, 1961).

The distribution of hydrogen in the telluric hydrogen corona is alculated by identifying the components of a fictitious hydrostatic istribution which are actually present in the real atmospheric disribution. The components which are clearly present are the captive allistic orbits and the escaping ballistic orbits which originate near he base of the exosphere. The components which are clearly absent re the hyperbolic orbits which originate in space; these consist of vo groups, those which do not intersect the base of the exosphere nd which return to space, and those which intersect the base of the xosphere and which are capture orbits. Trapped elliptic orbits, or atellite orbits, may or may not be present, but near the earth they re probably occupied. Each of these components can be evaluated s an explicit portion of a hydrostatic distribution, and the distriution calculated from the hydrostatic distribution in a straightrward manner. Calculations are presented for temperatures of 000° and 1500° K.

5132 PALAEOMAGNETIC EVIDENCE RELEVANT TO A CHANGE IN THE EARTH'S RADIUS.

.Cox and R.R.Doell.

ature (GB), Vol. 189, 45-7 (Jan. 7, 1961).

An attempt is made to estimate the radius of the earth from alaeomagnetic data The difference between the radii of the earth uring the Permian period and the present is not significant within he statistics of the information available. S.J.St-Lorant

5133 TIDAL DEFORMATIONS AND THE ORIGIN OF THE MOON. E.J.Öpik.

stron. J. (USA), Vol. 66, No. 2, 60-7 (March, 1961).

Results of a provisional survey of the ellipticities of lunar raters in selected areas of Kuiper's Atlas are discussed. The m.s. random ellipticity is found to be 0.070 near the centre, 0.096 ear the limb, and is probably due to oblique impact. Small preferenal components of ellipticity are indicated and interpreted as possle after-effects of past tidal deformations. Formulae for tidal-otational deformations of line elements on an elastic nonresisting urface are given. The smallness of the preferential effects is in itelf significant, without regard to their absolute value. They suggest at the craters were formed when the earth-moon distance was of e order of 30 000-50 000 km. The undamaged appearance of the craters except for impact erosion and flooding, and the absence of signs of major crustal deformations indicates that since crater formation the moon could not have been at a closer distance. From theoretical rates of accretion as based on probabilities of interplanetary collisions, possible modes of origin of the moon are discussed. If the pre-mare craters mark the end of a continuous process of accretion which built the moon, the observed small systematic deformations of the craters are only compatible with the moon having accreted from a cloud of fragments circling the earth in direct orbits at a distance of five to eight earth radii or greater. The assumption of different processes for accretion of the moon and for the formation of pre-mare craters leads to improbable consequences. Only when the preferential ellipticities are discounted as due to other causes or to chance, is it possible to accept the alternative of the moon having accreted from interplanetary material orbiting the sun. Accretion must then have run simultaneously with tidal evolution following initial tidal capture, the pre-mare craters having formed at a distance of over 200 000 km from earth as the final stage of this accretion.

5134 SOME CALCULATIONS ON THE THERMAL HISTORY OF THE MOON. B.Yu.Levin and S.V.Maeva.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 44-7 (July 1, 1960). In Russian.

For abstract, see Abstr. 14396 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 643-6 (Jan.-Feb., 1961)].

5135 SPHEROIDAL OSCILLATIONS OF THE MOON.

B.A.Bolt.

Nature (GB), Vol. 188, 1176-7 (Dec. 31, 1960).

Three different spherical gravitating lunar models are used to compute natural vibration periods in an attempt to provide basic data for lunar space research. Results for both fundamental, and first higher mode vibrations are tabulated; values of the free vibrational period range from 3.6 to 15.1 min. The analyses suggest that an ultra-long-period seismometer, or gravimeter, recording periods up to 16 min would be required to provide more detailed field information, if such natural vibrations are indeed present. D.R.Barber

5136 THE PLANET VENUS.

C.Sagan.

Science (USA), Vol. 133, 849-58 (March 24, 1961).

Review article on current theories of atmosphere, surface and possible biology.

5137 PHOTOELECTRIC PHOTOMETRY OF THE PENUMBRA DURING THE PARTIAL LUNAR ECLIPSE OF 24 MARCH 1959. A.Fresa.

RC Accad. Naz. Lincei (Italy), Vol. 29, No. 1-2, 46-51 (July-Aug., 1960). In Italian.

Experimental data are compared with the theory of Link (Abstr. 1742 of 1948) and is in reasonable agreement. J.M.Hough

5138 PHYSICAL AND ORBITAL BEHAVIOR OF COMETS.

R.E.Squires and D.B.Beard.

Astrophys. J. (USA), Vol. 133, No. 2, 657-67 (March, 1961).

As a comet approaches perihelion and the surface facing the sun is warmed, there is evaporation of the surface material in the solar direction. The effect of this unidirectional rapid mass loss on the orbits of the parabolic comets has been investigated, and the resulting corrections to the observed aphelion distances, a, and eccentricities have been calculated. Comet surface temperature has been calculated as a function of solar distance, and estimates have been made of the masses and radii of cometary nuclei. It was found that parabolic comets with perihelia of 1 a.u. may experience an apparent shift in 1/a of as much as +0.0005 a.u.^{-1} and that the apparent shift in 1/a is positive for every comet, thereby increasing the apparent orbital eccentricity over the true eccentricity in all cases. For a comet with a perihelion of 1 a.u., the correction to the observed eccentricity may be as much as −0.0005. The comet surface temperature at 1 a.u. is roughly 180° K, and representative values for the masses and radii of cometary nuclei are 6×10^{11} g and 300 m.

5139 COMET OBSERVATIONS.

G.Van Biesbroeck.

Astron. J. (USA), Vol. 66, No. 2, 96-102 (March, 1961).

Observations are reported for 14 comets, made in 1957-60, mostly with the Yerkes 24-inch and McDonald 82-inch reflectors.

5140 MAGNETIC PROPERTIES OF THE YARDȲMLINSK IRON METEORITE.

M.A.Kashkai, T.A.Ismail-Zade and V.I.Aliev.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 3, 568-70 (Jan. 21, 1961).
In Russian.

The meteorite which fell at Yardȳmlinsk in the Caucasus on November 24th 1959, is interesting as being the most recent of any kind, and also the first iron meteorite to fall on the earth since 1947. From the largest fragment, which weighed 127 kg, various test specimens were cut. First, a cube of edge 24 mm was used to measure the susceptibility and residual magnetization intensity. Further magnetic tests were then made on four equal rectangular prisms, of dimensions 4 × 4 × 24.75 mm. The measurements included those of the constant and alternating fields required to demagnetize the specimen, the relation between the intensity of magnetization and the temperature, and the Curie points of the ferromagnetic phases present. Various conclusions concerning the composition and history of the meteorite are drawn. [English translation in: Soviet Physics—Doklady (USA)]. N.Davy

5141 MICROMETEORITE MEASUREMENTS FROM 1958 ALPHA AND GAMMA SATELLITES. E.R.Manring.

Planet. Space Sci. (GB), Vol. 1, 27-30 (Jan., 1959).

Grid abrasion micrometeorite detectors mounted on 1958 Alpha and Gamma satellites give a maximum influx rate of particles 10 μ in diameter or larger for the period 1 February to 7 May, 1958. On 7 May, 1958 two detectors appeared to indicate impacts on 1958 Gamma. The failure within a few days of all electronics on the satellite open the possibility that a shower was encountered with meteor damage subsequently destroying electronics; or of an electronics failure which first manifested itself in the meteorite detection gear.

5142 THE DISTRIBUTION OF HELIUM-3 IN THE GRANT METEORITE AND A DETERMINATION OF THE ORIGINAL MASS. E.L.Fireman.

Planet. Space Sci. (GB), Vol. 1, No. 1, 66-70 (Jan., 1959).

The distribution of helium-3 in a slice of the Grant meteorite was determined by exposing it to slow neutrons and counting the converted tritium. The measured values ranged from 6.5×10^{-8} cm^3/g to 5.1×10^{-6} cm^3/g, with the highest value occurring near one edge of the slice. The helium-3 isopleths corresponding to 5.7×10^{-6} cm^3/g or less form closed loops which are not circles. This indicates that the meteorite was not spherical when it was exposed to extraterrestrial cosmic radiation. The variation of the helium-3 content with depth indicates that the average energy of the cosmic radiation to which it had been exposed was close to BeV. These measurements also indicate that the Grant meteorite, before it struck the earth's atmosphere, was a pear-shaped object with a mass of approximately 880 kg; and that 400 kg ablated from the meteorite in its plunge through the atmosphere.

5143 AMBIPOLAR DIFFUSION OF A METEOR TRAIL AND ITS RELATION WITH HEIGHT. E.L.Murray.

Planet. Space Sci. (GB), Vol. 1, No. 2, 125-9 (April, 1959).

Investigation of the relation between the ambipolar diffusion coefficient, D, of a meteor trail and height shows that considerable random fluctuations occur. It is however possible to obtain a statistical relation between these parameters. Regression lines have been derived for the relation between log D and height and it is shown that care must be exercised in the correct choice of the two possible regression lines.

5144 TEKTITES AS NATURAL EARTH SATELLITES. J.A.O'Keefe.

Science (USA), Vol. 133, 562-6 (Feb. 24, 1961).

Review article.

5145 DISTINCTION BETWEEN THE ELECTROMAGNETIC CONSTANTS OF TEKTITES AND LIBYAN DESERT GLASS AND THEIR EFFECT ON LUNAR SURFACE THEORY.

A.Olte and K.M.Siegel.
Astrophys. J. (USA), Vol. 133, No. 2, 706-17 (March, 1961).

The electromagnetic constants of tektites and Libyan Desert glass have been obtained in the laboratory, and it has been found that, for all tektites measured, the relative permittivities of tektites vary between 6 and 7.4, while the relative permittivity of Libyan Desert glass is 4.2. Thus it seems clear that Libyan Desert glass is not a tektite. Lunar radar scattering theory indicates that the material found in the scattering centres of the moon is significantly different from tektites as found on earth.

5146 THREE-COLOR PHOTOMETRY OF THE ZODIACAL LIGHT. A.W.Peterson.

Astrophys. J. (USA), Vol. 133, No. 2, 668-74 (March, 1961).

Thirteen recordings of the zodiacal light in three colours were analysed. The intensity variation along the ecliptic is similar to the variations obtained in previous studies. A change in slope of the intensity-curve at about 65° elongation, if interpreted as a particle-size indicator for the zodiacal cloud, suggests a size on the order of 1 μ. An average colour index similar to that of the sun is obtained, and no significant colour variation with position is found. No intensity effect is detected during a magnetic storm or at the beginning of a solar flare of importance 2+. The percentage polarization for elongations between 55° and 137° was found to be between 23 and 12 per cent.

5147 EXISTENCE OF NET ELECTRIC CHARGES ON STARS. L.Oster and K.W.Phillip; V.A.Bailey.

Nature (GB), Vol. 189, 43, 43-4 (Jan. 7, 1961).

Oster and Phillip claim that deductions from Bailey's hypothesis of a net negative charge on the sun are in conflict with observation. Suggested mechanisms for the production and maintenance of the solar charge would either imply the existence of strong electric fields and give rise to unobserved Stark effects in the outer layers of the sun, or would imply an outward drift of electrons with a consequent zero net charge. Possible terrestrial tests of magnetic effects implied by the hypothesis are discussed.

Bailey maintains that the above criticisms concern the origin of the solar charge rather than its existence; the arguments concerning the existence of strong electric fields below coronal regions would be relevant in a discussion of the location of the charge. Possible experimental tests are discussed, and some support for the hypothesis is claimed from magnetic effects derived from the findings of the space probe Pioneer V. See also following abstract. R.A.Newing

5148 APPARENT STEADY COMPONENT OF THE INTERPLANETARY MAGNETIC FIELD. V.A.Bailey.

Nature (GB), Vol. 189, 44-5 (Jan. 7, 1961).

See also preceding abstract. An analysis of the preliminary results of the Pioneer V magnetometer experiment suggests the existence of a steady component field perpendicular to the ecliptic, and probably directed from north to south. These findings are in general agreement with the field induced by motion around a negatively charged sun. The observed intensity of the field suggests that Pioneer V may have been surrounded by a diamagnetic cloud of ionized hydrogen. R.A.Newing

5149 THE TOPOLOGY OF THE SUN'S MAGNETIC FIELD AND THE 22-YEAR CYCLE. H.W.Babcock.

Astrophys. J. (USA), Vol. 133, No. 2, 572-87 (March, 1961).

Shallow submerged lines of force of an initial axisymmetric dipolar field of 8×10^{21} maxwells are drawn out in longitude by the differential rotation (after the suggestion of Cowling) to produce a spiral wrapping of five turns in the north and south hemispheres after 3 years. The amplification factor approaches 45, with a market dependence on latitude. Twisting of the irregular flux strands by the surface shallow layers in low latitudes forms "ropes" with local concentrations that are brought to the surface by magnetic buoyancy to produce bipolar magnetic regions (BMR s) with associated sunspots and related activity. The field intensity required for producing BMR s is reached at progressively lower latitudes according to the derived formula $\sin \phi = \pm 1.5/(n + 3)$, where n is the number of years since the beginning of the sunspot cycle. This accounts satisfactorily for Spörer's law and the Maunder "butterfly diagram". Sufficient flux rope for more than 10^3 BMR s is produced. "Preceding" parts of BMR s expand toward the equator as they age, to be neutralized by merging; "following" parts expand or migrate poleward so that their lines of force neutralize and then replace the initial dipolar field. This process, which involves severing and reconnection of lines of force in the corona, as well as expulsion of flux loops, need be only 1 per cent efficient. The result, after sunspot maximum, is a main dipolar field of reversed polarity. The process repeats itself, so that the initial conditions are reproduced after a complete 22-year magnetic cycle. This model accounts for Hale's laws of sunspot polarity and provides a qualitative explanation of the proponderance of "preceding" spots, of the forward tilt of the axes of older spots, of the recurrence of activity in preferred longitudes, and of Hale's chromospheric "whirls".

5150 RELATIONS BETWEEN PLASMA PHYSICS AND ASTROPHYSICS. L.Biermann.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 1008-11 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Some of these relations are discussed using a number of examples aken from solar physics and the physics of interplanetary space. The discussion refers to: (a) the theory of sunspots — influence of he magnetic fields on the energy flux and the static equilibrium, b) the energy balance of the solar chromosphere and corona, main- ained by progressive pressure or hydromagnetic waves emitted rom the hydrogen convection zone, (c) the structure of the solar magnetic fields at large distance from the surface, under the influ- nce of the sun's rotation and corpuscular emissions, (d) the proper- ies of interplanetary gaseous material, as deduced from geomag- etic observations, from the properties of the tails of certain comets nd the interrelation between these. The conclusion is drawn, hat the gaseous interplanetary medium does not co-rotate with the un, and that it cannot be different from the aggregate of the several omponents.

5151 REPORT OF THE NETHERLANDS EXPEDITION FOR THE OBSERVATION OF THE TOTAL SOLAR ECLIPSE ON OCTOBER 2, 1959. J.Houtgast.

Proc. K. Ned. Akad. Wetensch. B (Netherlands), Vol. 65, No. 5, 11-26 (1960).

A detailed account of observations made by a team of 8 Dutch bservers in the Canary Islands. Four major research projects were planned: (1) photography of the chromospheric spectrum in he range, 3885 to 4120 A, using a slit spectrograph with glass risms; (2) u.v. photography of the chromospheric spectrum be- ween 3400 and 4050 A with a concave off-axis mirror and grating; 3) photoelectric photometry of the extreme solar limb in four pectral regions centred at 4270, 4770, 5500, and 6200 A; (4) simul- aneous photography of prominences in continuous light (at 6200 A), nd in Hα light, with a double camera. During the eclipse period ll instruments functioned satisfactorily, and good images were ob- ained with the photographic equipment. It was not possible, how- ver, to obtain absolute intensities, as had been hoped, because of nterfering clouds. Provisional results are summarized.

D.R.Barber

5152 POLARIZATION AND INTENSITY STUDIES OF THE ECLIPSE OF OCTOBER 2, 1959.

.P.Ney, W.F.Huch, P.J.Kellogg, W.Stein and F.Gillett.

strophys. J. (USA), Vol. 133, No. 2, 616-42 (March, 1961).

Measurements of the polarization, in magnitude and direction, nd of the absolute intensity of the light from the solar corona were made on October 2, 1959, from two stations in French West Africa. en complete experiments were carried out in each of two wave- ength regions. The effective wave lengths were 4750 and 8300 A. n addition, the background skylight polarization and intensity were measured at both wave lengths. All measurements were absolute nd are given in units of the sun's average surface brightness. The measurements allow separation of the coronal light into F and K omponents and permit an upper limit to be set for the synchrotron adiation in the visible and infrared regions of the spectrum. Equa- rial electron densities are determined, and limits are set on the olar electron densities. The data are compared with previous bsolute measurements.

5153 THE SOLAR LYMAN-ALPHA EMISSION LINE. D.C.Morton and K.G.Widing.

strophys. J. (USA), Vol. 133, No. 2, 596-605 (March, 1961).

The Jefferies and Thomas theory of line formation by non- oherent scattering in a non-equilibrium chromosphere is applied the solar Lyman-α profiles recently photographed by a rocket pectrograph. A Planck function decreasing exponentially with creasing optical depth is assumed for the electron-temperature stribution. The theory successfully accounts for the cores of the bserved profiles with their two peaks separated by shallow reversals, t the predicted wings always fall off too sharply. The depths of e reversals show that the line originates in the regions of steepest mperature gradient. The separations of the peaks suggest electron mperatures of 70 000° K for the plages and 90 000° K for the sur- ounding darker areas. The absolute intensities require electron nsities ranging from 3×10^9 cm^{-3} for these respective regions.

5154 A COMMENT ON THE NRL SOLAR LYMAN-ALPHA RESULTS. J.T.Jefferies and R.N.Thomas.

strophys. J. (USA), Vol. 133, No. 2, 606-7 (March, 1961).

Supplementary comments are made on the Morton—Wilding analysis of the NRL Lyman-α observations; they serve to bring into sharper focus its relation to current attempts at analysis of self-reserved emission cores of collision-dominated lines for gradients of T_e, for chromospheric structure, and for differential structure between quiet sun and plage, sunspot and flare regions.

5155 THE BALMER : PASCHEN RATIO IN THE CHROMOSPHERE AND THE EQUILIBRIUM POPULATIONS OF HYDROGEN ANGULAR-MOMENTUM STATES.

L.L.House, R.G.Athay and H.Zirin.

Astrophys. J. (USA), Vol. 133, No. 2, 608-15 (March, 1961).

The work reported in this paper is a test of the hypothesis that the angular-momentum states of hydrogen are not populated according to their statistical weights. The anomalous ratio of the hydrogen Balmer to Paschen lines observed at the 1952 eclipse is investigated in relation to both observations and theoretical calculations. The Paschen decrement is used to test for a reduced population of states of higher angular momentum; such a depopulation of states was previously suggested as accounting for the anomalous ratio. The decrement does not confirm the suggestion. A statistical equilibrium analysis of the angular-momentum states is used to determine departures in the populations from their LTE values. The results indicate that departures are too small to give the observed Balmer: Paschen ratio. An additional calculation shows that it is reasonable to average together the substates of different angular momentum in hydrogen chromospheric calculations.

5156 HYDROMAGNETICS AND STELLAR STRUCTURE. K.D.Cole.

Nature (GB), Vol. 189, 31-3 (Jan. 7, 1961).

It is suggested that the radiation pressure should be expressed as the sum of electromagnetic and hydromagnetic terms p_{er} and p_{hr} in the equation of gravitational equilibrium. The p_{hr} term would be the dominant term in the solar corona, and would make possible a radial flux of momentum without an actual expansion of the corona. Geomagnetic disturbances and auroras could be explained in terms of hydromagnetic waves propagated from the sun to the earth, rather than in terms of the outstreaming of coronal gas.

R.A.Newing

5157 INTERPLANETARY GAS. III. A HYDRODYNAMIC MODEL OF THE CORONA. J.W.Chamberlain.

Astrophys. J. (USA), Vol. 133, No. 2, 675-87 (March, 1961).

The ionized interplanetary gas is viewed as an outer extension of the solar corona and is discussed with the scalar equations of hydrodynamic motion, continuity, and the first law of thermodynamics with heat conduction. This approach is contrasted with the evaporative theory of Pt II (Abstr. 6591 of 1960). Although there are differences in the results of the two theories arising from the different assumptions inherent in their formulations, similar solutions appear in the two cases. Specifically, the hydrodynamic treatment allows a solution in which both the expansion velocity and the density vanish at infinite distance. Indeed, it is argued that the high expansion velocities necessary for a steady "solar wind" require the basic assumption of an accelerating mechanism in the corona and that a solar wind is not an inevitable phenomenon. Further, coronal observations offer no basis for suspecting an outward expansion of the interplanetary gas faster than several kilometres per second at the earth's orbit — corresponding to a gentle "solar breeze". At the earth's orbit the temperature is governed by adiabatic equilibrium and is predicted to be in the neighbourhood of 15 000-20 000° K. Closer to the sun, conduction appears to become important, as advocated by Chapman, giving a much smaller temperature gradient. The density at the earth is computed to be around 30 electrons/cm^3.

5158 INTERPLANETARY GAS. IV. NEUTRAL HYDROGEN IN A MODEL, SOLAR CORONA. J.C.Brandt.

Astrophys. J. (USA), Vol. 133, No. 2, 688-700 (March, 1961).

The problem of the distribution of neutral hydrogen in a model solar corona is investigated. Hydrogen is considered as created by recombinations, destroyed by collisions and photoionization, and transported by diffusion. The diffusion cross-section is taken as that for charge exchange, and the effects of radiation pressure from solar Lyman-α are included. A model with an electron density near the orbit of earth of the order of $10^2/cm^3$ yields sufficient hydrogen beyond the earth to back-scatter solar Lyman-α and produce the observed night-sky radiation.

ON THE MAGNETODYNAMIC AND ADIABATIC EQUILIBRIUM OF A GASEOUS MASS WITH A UNIFORM ROTATIONAL AND GRAVITATIONAL MOTION. See Abstr. 5567

5159 A COMPARISON OF CEPHEIDS IN THE SMALL MAGELLANIC CLOUD WITH THOSE IN THE VICINITY OF THE SUN.

H.C.Arp and R.P.Kraft.

Astrophys. J. (USA), Vol. 133, No. 2, 420-9 (March, 1961).

The most recent observations of cepheids in the Small Magellanic Cloud and in the vicinity of the sun are examined. The two groups of cepheids are shown to differ in their period-frequency, period-amplitude, and period-colour relations. The two period-luminosity relations are shown to be quite similar, but it cannot be proved that the zero points are closer than ±0.5 mag. The SMC cepheids differ most from solar neighbourhood cepheids in having a large percentage of periods less than 4 days. Compared to galactic cepheids, SMC cepheids in this period range have much larger amplitudes of light-variation. A small difference, for this same period range, is that the SMC cepheids are about 0.1 mag. redder than those in the galaxy. By matching the two groups of cepheids together in different ways, true moduli (corrected for 0.25 mag. obscuration) of the SMC are obtained which range from $(m-M)_0 = 18.25$ mag. to $(m-M)_0 = 18.45$ mag. The population characteristics of the SMC cepheids are closer to "classical" cepheids than they are to population II (globular-cluster cepheids).

5160 THE ABUNDANCE OF LITHIUM IN T TAURI STARS: FURTHER OBSERVATIONS.

W.K.Bonsack.

Astrophys. J. (USA), Vol. 133, No. 1, 340-3 (Jan., 1961).

Spectrograms of the region of the Li I doublet for seven stars in the neighbourhood of the Taurus and Orion nebulosities indicate lithium abundances relative to the heavier metals of the order of one hundred times the solar value. These, together with earlier results, suggest that a high lithium abundance may be a common property of T Tauri stars in the neighbourhood of the sun.

R.A.Newing

5161 DISTRIBUTION OF HYDROGEN AND HELIUM IN THE INTERIOR OF THE STAR.

K.Kaminisi.

Kumamoto J. Sci. A(Japan), Vol. 3, No. 2, 111-14 (Feb., 1957).

The distribution is investigated on the assumption that the stellar structure is given by the polytropic gas sphere of index n = 3. The result suggests that in the deep interior of the star the chemical elements are well mixed even if there exists no appreciable convection current.

5162 THE SHAPE OF A ROTATING STAR CLUSTER.

I.King.

Astron. J. (USA), Vol. 66, No. 2, 68-70 (March, 1961).

A formula is derived for the ellipticity of a rotating star cluster in terms of a mean angular velocity and a mean density. It is identical with Clairaut's formula for a rigidly rotating body of uniform density. The observed ellipticities of globular clusters indicate that in some cases the rotational velocities are as large as the r.m.s. random velocities. Rotation causes slight increase in the rate at which a cluster ejects stars.

5163 NGC 5466.

J.Cuffey.

Astron. J. (USA), Vol. 66, No. 2, 71-82 (March, 1961).

The well-resolved globular cluster NGC 5466 is shown to have a colour-magnitude relation resembling those of M3 and other clusters of very different physical structure. The distance modulus 16.56 and the distance 20.5 kpc are derived. Absorption appears to be negligible. In the analysis of the plate residuals the 18 previously known variables are displayed conspicuously. A list of additional high-residual stars for future investigation as possible variables is given in the text. Three of them are definitely variables, and 22, suspects. The space distribution of the globular clusters north of galactic latitude 50^{0} is discussed in order to test the hypothesis that the clusters form a physical group, rather than a random sample of the halo population of the Milky Way system. The evidence suggests this may be the case, but does not conclusively establish it. Improvements in the distance for some of the objects are still needed to obtain the true relationship of these objects to each other and to the Milky Way system.

5164 THE FORNAX DWARF GALAXY. I. THE GLOBULAR CLUSTERS.

P.W.Hodge.

Astron. J. (USA), Vol. 66, No. 2, 83-4 (March, 1961).

Two new globular clusters have been found to belong to the Fornax dwarf galaxy. The properties and dimensions of the five known globular clusters are comparable to those of our galaxy. Measures of individual stars in each indicate that the magnitudes o their brightest stars are identical within 0.1 mag., but that the brightest stars of the main galaxy are 0.5 mag. brighter. The globular clusters have nearly ten times the projected star density of the main galaxy.

5165 POSSIBLE M-STAR MEMBERS OF NGC 6838.

C.B.Stephenson.

Astron. J. (USA), Vol. 66, No. 2, 85-7 (March, 1961).

In the vicinity of the metal-rich globular or globularlike cluste NGC 6838, bands of titanium oxide were found, on objective-prism plates, for six stars (one case previously known). Four of these stars are within one cluster radius of the centre and fall at the upp end of the giant branch of the colour-magnitude diagram. An objection to their cluster membership is that they require the diagram either to be abnormal or little reddened; but independent evidence already suggests the same problem for the colour-magnitude diagram. No definite conclusions about cluster membership of the M stars can be drawn, but identification charts for them are furnishe

5166 MAGNETIC MIRRORS IN THE MILKY WAY GALAXY.

L.Marshall.

Nuovo Cimento (Italy), Vol. 19, No. 1, 6-19 (Jan. 1, 1961).

It is shown that the present day velocity distribution of the Milky Way Galaxy amplifies the magnetic field in the galactic arm by stretching the existing lines of force in such a way as to produc magnetic mirrors in the regions between 4 and 10 kps radius. The strength of the mirrors is increasing with time so that, effectively a mirror of given strength seems to be moving out along the arm. It is suggested that these mirrors, fixed at constant radius but effectively moving, are important in production of cosmic rays, an it is shown that the appropriate constants relating to the mirrors are compatible with a Fermi accelerator mechanism of first order dependence on effective mirror velocity. The energy for this process is derived from differential rotation energy of which there is an adequate supply.

Radioastronomy

Y-TYPE CIRCULATOR SWITCH FOR 21 cm MASER RADIOMETER. See Abstr. 5578

5167 SPECTRAL OBSERVATIONS OF SOLAR RADIO BURSTS. I. RECEIVING EQUIPMENT.

A.R.Thompson.

Astrophys. J. (USA), Vol. 133, No. 2, 643-8 (March, 1961).

The spectrum of solar radio bursts is observed at the Harvar Radio Astronomy Station, Fort Davis, Texas, over the frequency ranges 25-580 Mc/s and 2100-3900 Mc/s. The observations cove period from sunrise to sunset of each day and were commenced in October, 1956, over three octaves of the present frequency range. Six sweep-frequency receivers are used, each of which covers almost one octave of the frequency spectrum. The aerials for the frequencies below 100 Mc/s consist of broad-band dipoles mounte over a reflecting screen, and for the frequencies above 100 Mc/s, consist of an equatorially mounted paraboloid with four primary feeds. The outputs of the receivers are displayed on six cathode-ray tubes and are recorded photographically. After sunset each d the equipment is calibrated in intensity by recording signals of kn power from a noise generator. A table relating the calibration-power levels to the intensity of equivalent solar signals at a numb of frequencies is given.

LUNAR RADAR SCATTERING, COMPARISON SURFACE ELECTROMAGNETIC PROPERTIES WITH THOSE OF TEKTITES AND LIBYAN DESERT GLASS. See Abstr. 5145

5168 OBSERVATIONS OF JUPITER AT A WAVE LENGTH OF 10 cm.

R.M.Sloanaker and J.W.Boland.

Astrophys. J. (USA), Vol. 133, No. 2, 649-56 (March, 1961).

Two series of measurements of the radiation from the planet Jupiter were made at wave lengths of 10.3 and 10.2 cm, using the same radiometer and the 84 ft reflector at the U.S. Naval Researc Laboratory. Measurements were made from June to August, 195 and in October, 1959. The mean apparent black-body temperature derived from the measurements are $640^{0} \pm 85^{0}$K standard error f the 1958 measurements and $315^{0} \pm 65^{0}$K standard error for the 19 measurements. It is concluded that the observed change in intens of about 2 to 1 between 1958 and 1959 is real and may be related t larization of the radiation or to a correlation with solar activity. addition, the 1958 measurements show some evidence of short-ne variability, possibly correlated with the rotation of the planet.

5169 LUNAR BRIGHTNESS VARIATIONS WITH PHASE AT 4.3 mm WAVE LENGTH. R.J.Coates.
strophys. J. (USA), Vol. 133, No. 2, 723-5 (March, 1961).

5170 ANALYSIS OF A TYPE OF ROUGH-TRAIL METEOR ECHO. B.A.McIntosh.
anad. J. Phys., Vol. 39, No. 3, 437-44 (March, 1961).

For a particular type of meteor echo, the variation of echo ration with atmospheric height is examined. Theory based on an itially rough meteor trail is substantiated by showing that atmos-eric scale heights calculated from measurements on these hoes are in agreement with generally accepted values.

5171 THE GALAXIES IN THE RADIO SOURCE 3C278. J.L.Greenstein.
strophys. J. (USA), Vol. 133, No. 1, 335-7 (Jan., 1961).

This source has been identified with one or both members of e close pair of elliptical galaxies NGC4782—4783, which is tuated in the southern extension of the Virgo cluster. Radial elovity measurements show that they are not cluster members it are at a distance of about 56 megaparsecs and hence have an osolute magnitude of −20.8 confirming the suggestion that extra-ilactic radio sources have very high optical luminosity. The mass id mass/luminosity ratio together with the dissimilarity in spectra iggest a chance encounter rather than a permanently bound pair. n the other hand the absence of emission lines is suggestive of an d pair of systems which have suffered repeated collisions. It is iggested that between collisions the gas may be rejuvenated from volving red giants and may be sufficient for synchrotron emission hen gas and fields are compressed on collision. The system may epresent a group of radio emitters which are bound, massive, ouble systems of lower radio luminosity than exceptional emitters ke Cygnus A, but which, instead of being significant emitters only nce, may be possibly recurrent. C.Hazard

pace Research

5172 I.G.Y. ROCKETS AND SATELLITES: A REPORT ON THE MOSCOW MEETINGS, AUGUST 1958.
.W.Kellogg.
lanet. Space Sci. (GB), Vol. 1, No. 1, 71-84 (Jan., 1959).

A report of the Fifth Meeting of CSAGI (Committee Speciale de Annee Ge Geophysique Internationale) held at Moscow from 31 July to August 1958.

5173 LIMITATIONS ON SPACE FLIGHT DUE TO COSMIC RADIATIONS. H.J.Curtis.
cience (USA), Vol. 133, 312-16 (Feb. 3, 1961).

Review article.

COSMIC RADIATION PROBLEMS IN ASTRONAUTICS. See Abstr. 4813

5174 OBSERVATIONS OF THE RUSSIAN SATELLITES AND THE STRUCTURE OF THE OUTER TERRESTRIAL ATMOSPHERE. H.K.Paetzold.
Planet. Space Sci. (GB), Vol. 1, No. 2, 115-24 (April, 1959).

The launching of the artificial earth satellites gave the opportunity to gain some direct information about the outer region of the earth's atmosphere. Radio observations were mostly made on 20 Mc/s with a direction-finder, which uses three pairs of adcock-antennas. The direction of the wave front and the amplitude of the received signals can be measured at the front of a television tube. A movie-camera registers the pictures with a time resolution of 0.1 sec. The accuracy of the measured azimuths is about 0.5°. For 1957 $\alpha 1$, 1957β and 1958 $\delta 1$, optical observations of the German Moonwatch-groups were used. Further orbit data were obtained from the Moonwatch Headquarters, Cambridge, Mass., the Air Force Cambridge Research Centre, Bedford, Mass., and the Vanguard Computing Centre, Washington.

5175 APPROXIMATE POSITIONS OF ARTIFICIAL SATELLITES OBTAINED WITH THE BAKER-NUNN SCHMIDT CAMERA. (4). OBSERVATION PERIOD; 1959 OCT.-DEC.
Tokyo astron. Bull. (Japan), No. 133, 1679-94 (Oct. 15, 1960).

5176 RE-ENTRY OF THE SPUTNIK I ROCKET. I.Harris and R.Jastrow.
Planet. Space Sci. (GB), Vol. 1, No. 1, 37-9 (Jan., 1959).

5177 DECAY OF SPIN IN SPUTNIK I. J.W.Warwick.
Planet. Space Sci. (GB), Vol. 1, No. 1, 43-9 (Jan., 1959).

A secular change took place in the spin-fading rate during the three weeks of observation of the radio transmissions from Sputnik I, between 4 October 1957 and 24 October 1957. This effect allows a determination of atmospheric density near the perigee point. For an assumed atmospheric scale height of 30 km, a value 3.8×10^{-13} g cm^{-3} for the density at 220 km is derived. Some fluctuations in the spin decay appear to be real, and may result from small changes in the orientation of the spin axis within the satellite. An alternative interpretation in terms of charged drag resulting from motion of the satellite through the ionospheric plasma, requires a charge of at least 10^4 V on the satellite. This charge might be acquired in the auroral zone.

5178 LOSS OF MASS IN ECHO SATELLITE. I.I.Shapiro and H.M.Jones.
Science (USA), Vol. 133, 579 (Feb. 24, 1961).

Corrections to a previous paper. See Abstr. 50 of 1961.

PHYSICS

GENERAL

5179 ANNIVERSARIES IN 1961 OF INTEREST TO PHYSICISTS.
E.S.Barr.
Amer. J. Phys., Vol. 29, No. 4, 234-48 (April, 1961).

During the year 1961, there will be major anniversaries of the birth or death of 11 men who have figured importantly in the development of physics. Brief accounts of their lives and contributions are presented here.

5180 PROFESSOR H.W.B.SKINNER, F.R.S. (1900-1960).
R.E.Peierls.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 1-4 (Feb., 1961).

A brief biography, with stress on Skinner's physics work and a list of his publications (29 refs.).

5181 PHYSICS EDUCATION.
J.W.Buchta.
Phys. Today (USA), Vol. 14, No. 1, 28-9 (Jan., 1961).

An account of the international conference held in Paris, 28 July-4 August, 1960 under the auspices of the International Union of Pure and Applied Physics.

5182 UNDERGRADUATE CURRICULA FOR PHYSICS MAJORS IN A SELECT SAMPLE OF INSTITUTIONS. C.B.Clark.
Amer. J. Phys., Vol. 29, No. 4, 219-21 (April, 1961).

The course requirements in physics and mathematics for undergraduate physics majors at 50 institutions in the United States is tabulated. The information was obtained by an inspection of the official publications of the institutions. Other pieces of miscellaneous information concerning the curricula are reported.

5183 DISTRIBUTION OF TIME IN GENERAL PHYSICS COURSES. M.W.White.
Amer. J. Phys., Vol. 29, No. 5, 291-3 (May, 1961).

Because of the steadily increasing number of students in the general physics courses and the shortage of teachers, many physics departments are searching for methods of handling larger numbers of students per section. About 100 of the larger physics departments in the US were queried to obtain information concerning their methods for handling these classes. The data received indicate considerable variations in the distribution of class hours between recitation, lecture, and laboratory. There is some evidence of a trend toward more hours per week in larger lecture groups, with fewer hours devoted to recitation sections. The time devoted to laboratory work has been slightly reduced in these courses in recent years.

5184 FILMS FOR STUDENTS OF PHYSICS.
R.L.Weber.
Amer. J. Phys., Vol. 29, No. 4, 222-33 (April, 1961).

Some 450 films helpful for instruction in physics, mostly at the college level, are listed by field. Addresses of distributors are given. Sources of information about domestic and foreign films are included.

5185 SCALE TIMES AND SCALE LENGTHS OF VARIABLES: WITH GEOMAGNETIC AND IONOSPHERIC ILLUSTRATIONS. S.Chapman.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 424-32 (Feb., 1961).

The conception of the atmospheric scale height (relating to proportionate variation of barometric pressure) is generalized to apply to any scalar and vector functions of time and/or position. Examples are given relative to magnetic fields and the ionosphere. The scale length and scale time here defined enable precision to be given to often used terms such as "slow variation", distance (or time) "small in relation to the scale of variation" of another quantity.

GRAVITATION . RELATIVITY

5186 COVARIANT FORMALISM FOR PARTICLE DYNAMICS. A.Peres and N.Rosen.
Nuovo Cimento (Italy), Vol. 18, No. 4, 644-50 (Nov. 16, 1960).

In the usual covariant formulations of particle dynamics difficulties are encountered that appear to be associated with the constraint $u_\kappa u^\kappa = 1$, imposed on the four-velocity. It is proposed to remove these difficulties by putting the Lagrangian into a suitabl form, so that this condition on the velocities is a consequence of equations of motion together with appropriate initial conditions, rather than a constraint.

5187 REMARK CONCERNING THE GRAVITATIONAL INTE ACTION OF MATTER AND ANTI-MATTER.
F.Winterberg.
Nuovo Cimento (Italy), Vol. 19, No. 1, 186 (Jan. 1, 1961).

The suggestion that anti-matter might repel matter gravitationally is shown to be inconsistent with a gravitational red-shift o light rays, together with conservation of energy. C.W.Kilmist

5188 APPARENT SHAPE OF LARGE OBJECTS AT RELATIVISTIC SPEEDS. M.L.Boas.
Amer. J. Phys., Vol. 29, No. 5, 283-6 (May, 1961).

It has been recently recognized that there is a difference between the measured Lorentz contracted shape of an object moving at relativistic speed and the shape as seen by a single observer. The case of an object which subtends a small solid angle at the observer has been discussed by several authors. Thi paper discusses objects so large or so near that the subtended solid angle cannot be considered small, and gives simple proofs t spheres always present a circular outline and that straight lines may appear curved. These results are applied to revise Gamow's well-known picture of the bicyclist seen by Mr. Tompkins.

5189 RELATIVITY OF MOVING CIRCUITS AND MAGNETS. D.L.Webster.
Amer. J. Phys., Vol. 29, No. 4, 262-8 (April, 1961).

Many traditional rules that are contrary to special relativity have persisted in elementary textbooks. The persistence of mos of them may be primarily a result of a natural but mistaken neglect of a term in one of the Lorentz transformations. Rules required by relativity to replace these older rules are discussed here with illustrative examples.

5190 THE SPECIAL THEORY OF ELECTROMAGNETISM.
B.L.Coleman.
Nature (GB), Vol. 189, 476-7 (Feb. 11, 1961).

The law of addition of collinear velocities, as derived from th Lorentz transformation in special relativity, can be applied analogously to the addition of collinear electric vectors if the inverse square law of field strength of an electron is stated:

$$\frac{d\varphi}{dr} = -\frac{e}{(\sigma^2 + e^2\chi^{-2})^{1/2}},$$

where φ is the potential, $d\sigma^2 = dr^2 - \chi^{-2}d\varphi^2$, σ is the "electric interval" and χ is a universal constant. J.K.Skwirzyns

5191 GENERAL RELATIVITY WITHOUT COORDINATES.
T.Regge.
Nuovo Cimento (Italy), Vol. 19, No. 3, 558-71 (Feb. 1, 1961).

Gives an approach to the theory of Riemannian manifolds whic avoids the use of co-ordinates. Curved spaces are approximated higher-dimensional analogues of polyhedra. Among the advantage of this procedure are the possibility of condensing into a simplifie model the essential features of topologies like Wheeler's wormhol and a deeper geometrical insight.

5192 HEISENBERG REPRESENTATION IN CLASSICAL GENERAL RELATIVITY.
R.Arnowitt, S.Deser and C.W.Misner.
Nuovo Cimento (Italy), Vol. 19, No. 4, 668-81 (Feb. 16, 1961).

The energy of the gravitational field (as of any other system) not always the numerical value of the Hamiltonian (for example, in a Hamilton—Jacobi formulation). The authors define a classic "Heisenberg representation" which excludes Hamilton—Jacobi-lik canonical transformations. Ordinarily, within the Heisenberg representation, there remains only the possibility of time-independent canonical transformation among the dynamical variables. However, he freedom of co-ordinate transformations in general relativity allows many extra "canonical" transformations not found in conventional Lorentz covariant theory. This wider class of canonical ormalisms possess all the properties usually associated with the Heisenberg picture in that in each formalism the measurable quantiies, $g_{\mu\nu}(t)$, are obtained from knowledge of the canonical variables at the same time without any explicit co-ordinate dependence. Further, the Hamiltonian is a constant of motion. Only in Heisenberg frames is the Hamiltonian to be associated with the energy of he system. In spite of the additional freedom of canonical transormations (due to the freedom of co-ordinate change mentioned above), it is shown that the Hamiltonian is numerically the same for a fixed state of the gravitational field in any Heisenberg representaion. The energy is then a uniquely definable quantity in the theory.. n the process, it is established that two Heisenberg frames can differ by co-ordinate transformations that depend only on the canonical variables and not explicitly on the co-ordinates. These transormations must also preserve the property that at spatial infinity he metric become Lorentz so that the physical boundary conditions be unaltered.

5193 NONCLASSICAL STRUCTURE OF THE ENERGY—MOMENTUM TENSOR OF A POINT MASS SOURCE FOR THE SCHWARZSCHILD FIELD. F.R.Tangherlini.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 147-9 (Feb. 1, 1961).

It is claimed that the Schwarzschild solution (with $g_{00} = 1 - 2m/r$) considered as a solution for all r requires a definite form for the (singular) energy tensor at the origin. The physical significance of his is not clear [though a concluding paragraph argues that it is connected with the principle of equivalence]. C.W.Kilmister

QUANTUM THEORY

(Applications of quantum theory to elementary particles and nuclei are included under Nuclear Field Theory)

5194 SYSTEMS OF OBSERVABLES IN QUANTUM MECHANICS. J.M.Jauch.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 711-26 (1960).

The self-adjoint linear operators which represent the observables of a physical system are in general not an irreducible system. Because a complete set of commuting observables must determine the state of a physical system unambiguously the observables generate an algebra of operators which must contain a maximal Abelian subalgebra. The structure of such algebras is investigated and it is shown by applying the theory of the direct integral of Hilbert spaces that there exists always a unique canonical representation of the Hilbert space as a direct integral in such a way that the transformations which are induced by the observables in the component subspaces are irreducible.

5195 QUANTUM THEORY IN REAL HILBERT SPACE. E.C.G.Stueckelberg.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 727-52 (1960).

Relativistic quantum theory is brought to a form, where all operators, including time reversal, are linear: Hilbert space is real. Instead of the imaginary number $i = \sqrt{-1}$, an operator J ($J^2 = -1$) is introduced, which commutes with all observables and with the orthogonal operators representing ortho-chronous Lorentz transformations, and anti-commutes with the orthogonal representation of pseudo-chronous Lorentz transformations. It is shown, that J is necessary in order to have an uncertainty principle. Furthermore it follows that momentum-energy and angular momentum-centre of energy are pseudo-chronous quantities. Therefore, the Hamiltonian operator does not change sign under time reversal. Lorentz transformations are considered as passive (coordinate frame) transformations. The following topics are also discussed: possible generalization of quantum theory involving nonlinear operators; the dictionary between conventional theory in complex Hilbert space and the proposed formalism in real Hilbert space the dictionary between a quantum theory in quaternion Hilbert space and real theory. Also an error, frequently found in literature, concerning the present representation of the Lorentz group is pointed out.

5196 INTEGRAL REPRESENTATIONS FOR THE VACUUM EXPECTATION VALUE OF THREE SCALAR LOCAL FIELDS. G.Källen and J.Toll.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 753-72 (1960).

The integral formula of Bergman and Weil for the representation of an analytic function of several complex variables is applied to the vacuum expectation value of three scalar local fields. Several versions of the result are given. The various formulae are connected with each other by integral transformations (Hankel transforms). One of the versions reads

$$F(z) = \int_0^\infty d^3a \prod_{k=1}^{3} \Delta_2^{(+)}(z_k, a_k) \int_0^\infty dr \sum_{i=0}^{3} \psi_i(a,r) f_i(z,r).$$

The functions $\psi_i(a,r)$ are arbitrary weight functions. It is assumed that both the weights and the function F(z) are sufficiently bounded at infinity. Three terms with i = 1, 2 or 3 can be related to simple Feynman diagrams, while an interpretation of the remaining term has not been found.

5197 ZERO-POINT ENERGY AND ARRANGEMENT OF NON-COMMUTING FACTORS IN THE HAMILTONIAN. C.P.Enz and A.Thellung.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 839-48 (1960). In German.

In general, the arrangement of non-commuting factors in a Hamiltonian H is not completely determined by the requirement that H must be Hermitian. In the case of the harmonic oscillator the zero point energy can be removed by a perfectly legitimate reordering of the factor p and q (i.e. by writing H as a "normal product"). This raises the question whether physical effects that confirm the existence of a zero-point energy mean that only one particular choice of the order of the p's and q's in H is correct. For the case of the sublimation pressure of isotopes and of the Casimir effect this is discussed in full detail. It is shown that the general principles of quantum mechanics (without the addition of any empirical prescriptions about the order of factors) lead to a unique result for such measurable effects, although the Hamiltonian itself is not uniquely defined.

5199 CAUSALITY AND THE LORENTZ GROUP. M.Neuman.

Nuovo Cimento (Italy), Vol. 19, No. 3, 443-66 (Feb. 1, 1961).

A definition of causality, different from the one currently employed in field theory, is introduced. Its relation to the Lorentz group and to relativity theory is clarified. It leads to a reduction of the S-matrix, appropriate to dispersion theory, that is not subject to some limitations hitherto encountered. The mathematical considerations appearing in the course of this reduction are discussed.

5198 THE METHOD OF PERTURBATIONS FOR AN OPERATOR OF SIMPLE STRUCTURE. B.L.Livshits.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 800-3 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 18571 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 827-30 (Jan.-Feb., 1961)].

VARIATIONAL PRINCIPLES FOR NON-STATIONARY QUANTUM-MECHANICAL PROBLEMS AND PERTURBATION THEORY. See Abstr. 4778

5200 RELATIVISTIC PARTICLE DYNAMICS. B.Bakamjian.

Phys. Rev. (USA), Vol. 121, No. 6, 1849-51 (March 15, 1961).

It is shown that an instant form of relativistic particle dynamics can be constructed which displays the symmetry properties inherently present in the point form. In this new instant form, interaction terms are introduced in the energy momentum four-vector of the system; physically this is more justifiable than the more customary method of having interaction terms appear in the energy and the three generators of the Lorentz group which give the three infinitesimal displacements in velocity.

5201 ON THE BOUND STATES OF A GIVEN POTENTIAL. J.Schwinger.

Proc. Nat. Acad. Sci. (USA), Vol. 47, No. 1, 122-9 (Jan., 1961).

Gives an alternative derivation of the inequality due to Bargmann (Abstr. 2208 of 1953), giving an upper bound to the number of bound states of a given spherically-symmetric potential, and extensions to

give better estimates of the number and energies of bound states, and to include potentials that are not spherically symmetric.
J.Hawgood

5202 QUANTUM MECHANICAL THREE-BODY PROBLEM. II.
L.Eyges.
Phys. Rev. (USA), Vol. 121, No. 6, 1744-57 (March 15, 1961).

For previous part, see Abstr. 886 of 1960. A method is presented for treating the following quantum mechanical three-body problem: to find the ground-state eigenvalue and eigenfunction for a system of three identical particles between any pair of which there is an attractive central force. An essential point of the method is to assume the wave-function Ψ has a special analytic form,

$$\vec{\Psi} = \psi\,(\vec{r}_{12}, \vec{\rho}_3\,) + \psi(\vec{r}_{13}, \vec{\rho}_2) + \psi(\vec{r}_{23}, \vec{\rho}_1),$$

where

$$\vec{r}_{12} = \vec{r}_1 - \vec{r}_2,\ \vec{\rho}_3 = \vec{r}_3 - \tfrac{1}{2}\,(\vec{r}_1 + \vec{r}_2)$$

and $\vec{r}_{13}$, $\vec{\rho}_2$, and $\vec{r}_{23}$, $\vec{\rho}_1$ are defined analogously. The Schrödinger equation for the system can then be written as an integral equation for $\phi(\vec{k}, \vec{\kappa})$, the Fourier transform of ψ. This is expanded in Legendre polynomials,

$$\phi(\vec{k}, \vec{\kappa}) = \sum_{l=0}^{\infty} \phi_l(k, \kappa) P_l(\cos\gamma),$$

and yields a set of coupled integral equations for the $\phi_l\,(k, \kappa)$. These can be truncated and to a good approximation one can neglect all ϕ_l except ϕ_0, thereby reducing the problem to a single integral equation for a function of two variables. An iterative scheme is proposed for solving this equation for the ground-state eigenfunction, and a simple but accurate nonvariational method is suggested for deriving the energy eigenvalue therefrom. This proposed solution is tested by working it out in detail for the case of exponential interparticle potentials. The results for the eigenvalue compare favourably with variational calculations by other authors. Finally, the accuracy of the approximations and the possible sources of error in the wave-function are discussed.

STATISTICAL MECHANICS
TRANSFER PROCESSES

5203 SUCCESSIVE APPROXIMATION METHODS IN CLASSICAL STATISTICAL MECHANICS. G.E.Uhlenbeck.
Suppl. to Physica (Netherlands), Vol. 26, S17-S27 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Some of the terms used in the theory of graphs are defined. The derivation of the Mayer expansion for non-ideal gases is discussed. It is shown that the more complex or connected a graph is the smaller the corresponding integral is likely to be, and the distribution of complexities is discussed. The expansion, with modifications, can be applied to a plasma.
D.J.Thouless

5204 PARTITION FUNCTIONS AS AVERAGES OF FUNCTIONALS OF GAUSSIAN RANDOM FUNCTIONS.
A.J.F.Siegert.
Suppl. to Physica (Netherlands), Vol. 26, S30-S35 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). It is shown how the partition function in statistical mechanics can be written as an average of functionals of random functions.
D.J.Thouless

5205 ON THE DYNAMICAL DERIVATION OF EQUILIBRIUM STATISTICAL MECHANICS.
I.Prigogine, R.Balescu, F.Henin and P.Resibois.
Suppl. to Physica (Netherlands), Vol. 26, S36-S48 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The process by which equilibrium is set up in a system can be studied by means of a diagrammatic technique. This is illustrated by a scattering problem, and the ideas needed for classical and quantum many-body systems are outlined. Correlations are built up to give the equilibrium properties described by Mayer diagrams.
D.J.Thouless

5206 ON THE CLASSICAL LIMIT OF THE DIAGRAM EXPANSION IN QUANTUM STATISTICS.
T.W.J.M.Janssen.
Suppl. to Physica (Netherlands), Vol. 26, S75-S77 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The relation between quantum statistical perturbation theory and the Mayer cluster expansion is exhibited.
D.J.Thoules

5207 THERMODYNAMICS, STATISTICS, AND INFORMATION. L.Brillouin.
Amer. J. Phys., Vol. 29, No. 5, 318-28 (May, 1961).

A short summary of the two principles of thermodynamics, together with the statistical interpretation of entropy, is given. It is shown that the definition of "information" leads to a direct connection between information and the negative of entropy (abbreviated: negentropy). Every experiment consumes negentrop (increases entropy) and yields information. The negentropy principle of information is a generalization of Carnot's principle, and is explained on different examples. The informational value of physical laws is discussed and the role of creative thinking emphasized.

5208 THE PRINCIPLE OF CAUSALITY AND THE SECOND LAW OF THERMODYNAMICS. Yu.P.Terlekskii.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 329-32 (July 11, 1960). In Russian.

For abstract, see Abstr. 18966 of 1960. [English translation i Soviet Physics—Doklady (USA), Vol. 5, No. 4, 782-5 (Jan.-Feb., 1961)].

5209 THERMODYNAMIC THEORY OF RELAXATION PROCESSES IN SYSTEMS WITH SUPPLEMENTARY PARAMETERS. V.T.Shmatov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 570 (1958). In Russian.

A re-derivation of some of the results of the thermodynamic theory of relaxation, with special reference to the different relaxation times appearing when different external variables are held constant. [English translation in: Phys. Metals and Metallograph (GB), Vol. 6, No. 3, 181-3 (1958)].
R.O.Davi

5210 ON THE GENERAL THEORY OF THE APPROACH T EQUILIBRIUM. II. INTERACTING PARTICLES.
F.Henin, P.Résibois and F.Andrews.
J. math. Phys. (USA), Vol. 2, No. 1, 68-90 (Jan.-Feb., 1961).

For Pt I, see Abstr. 16618 of 1960. The general method described is applied to a system (a homogeneous fluid) of interacting particles. A full use is made of the diagram technique due to Prigogine and Balescu. The distribution function is Fourier analysed and each Fourier coefficient is decomposed into two parts: one (ρ whose evolution results from scattering processes and which obey a diagonal differential equation; the second one (ρ''), whose evoluti is due to direct mechanical interactions which build the correlatio described by the Fourier coefficient. The ρ'' can be expressed in terms of functions ρ' corresponding to lower correlations. The velocity distribution function is dealt with first. Only scattering processes contribute to the evolution of this function. The equatio obtained ensure evolution of this function to the correct equilibriu value at any order in the concentration C and the coupling constant λ. Then the authors study the asymptotic behaviour of the Fourier coefficients which describe correlations among the particles. The part ρ' of these coefficients corresponding to scattering processes vanishes for large time. In other words, scattering processes pla a fundamental role in the establishment of the correct velocity distribution function, but once this is achieved they become ineffective. The correct equilibrium correlations, which in equilibrium theory are described in terms of cluster diagrams, are built by direct mechanical interactions among the particles involve in the correlation. A detailed proof is given up to order C^2. The extension to higher orders does not introduce any new feature.

5211 ON THE GENERAL THEORY OF THE APPROACH TO EQUILIBRIUM. III. INHOMOGENEOUS SYSTEMS.
F.C.Andrews.
J. math. Phys. (USA), Vol. 2, No. 1, 91-5 (Jan., 1961).

The evolution equation is found for a singlet distribution functi in a fluid containing macroscopic inhomogeneities. The equation, a generalization of the Boltzmann equation, derived from the Liouvil equation, may be written formally to any order in either concentration or strength of interaction. The quantity f_1 is found to be a unctional only of itself and other f_1's. It is then shown that initially resent correlations are destroyed during the same relaxation time s in homogeneous systems. One can then write formally to any rder the equation for a reduced s-particle distribution function f_s, hich proves to be a functional of a product of f_1's, all the time ependence of the f_s being lodged in the f_1's for times greater than he relaxation time.

5212 DOUBLE-TIME GREEN FUNCTIONS IN STATISTICAL PHYSICS. D.N.Zubarev.

Jspekhi fiz. Nauk (USSR), Vol. 71, No. 1, 71-116 (May, 1960). n Russian.

The use of Green's functions that depend on two time variables it a given tempertaure is reviewed. Advanced and retarded functions ire used rather than causal functions becuase their Fourier transorms can be continued into the complex plane. These functions satisfy coupled equations of motion with boundary conditions given oy spectral theorems. If the Green's functions are calculated by lecoupling the equations of motion, thermodynamic functions can be ound. The Green's functions also arise in the theory of weak nonequilibrium processes, and so transport coefficients, such as the electrical conductivity, can be calculated. The theory is illustrated oy considering perfect quantum gases, the theory of superconductivity, ferromagnetism, and the electron-lattice interaction. The Green's functions can be calculated exactly for perfect quantum gases. It is shown that in superconductivity theory, in the limit of nfinite volume, the equations for the Green's function can be solved exactly if interactions between particles of opposite momentum only ire taken into account. The "trivial" solution is inconsistent below the critical temperature, as it gives a singularity in the complex plane. An equation for a ferromagnetic material is obtained which makes sense over the whole temperature range; this theory embraces the spin-wave theory, the molecular field theory, and the perturbation theory of paramagnetism. The theory of electron and phonon energies in a normal metal and the electrical conductivity of a semiconductor are discussed. [English translation in: Soviet Physics—Uspekhi (USA), Vol. 3, No. 3, 320-45 (Nov.-Dec., 1960)]. D.J.Thouless

5213 QUANTUM STATISTICS OF DISTRIBUTIONS WITH MAXIMUM RANDOMNESS. M.Castañs Camargo.

An. Real Soc. Espan. Fis. Quim. (Spain), Vol. 55A, No. 11-12, 305-8 (Nov.-Dec., 1959). In Spanish.

An intuitive meaning of Bose—Einstein and Fermi—Dirac statistics is obtained by maximizing γ (uncertainty or ramdomness) as applied to the number of particles per cell probabilities in the μ phase space.

5214 EXCHANGES OF ENERGY IN QUANTIZED SYSTEMS. J.Andrade e Silva, F.Fer, P.Leruste and G.Lochak.

C.R. Acad. Sci. (France), Vol. 251, No. 22, 2482-3 (Nov. 28, 1960). In French.

In a stationary assembly, the eigenvalues are quantized and the amplitudes of the eigenfunctions are uncorrelated. In a transistory regime energy can be exchanged between the different eigenvalues, in the stationary regime these exchanges average out to zero. It is suggested that the quantization may really be a consequence of the exchanges of energy between the systems, and a simple model is given in illustration. H.N.V.Temperley

5215 NON-LINEARITY, LIMITING TRAJECTORIES, AND QUANTIZATION.

J.Andrade e Silva, F.Fer, P.Leruste and G.Lochak..

C.R. Acad. Sci. (France), Vol. 251, No. 23, 2662-4 (Dec. 5, 1960). In French.

The reconciliation of the necessity for a nonlinear theory (Abstr. 2705 of 1961 and preceding abstract) and of the success of the linear theory in explaining energy quantization is discussed. An analogy is drawn between the concept of limiting trajectories encountered in differential equation theory and the asymptotic states of a system which are described by linear equations. J.S.Dowker

5216 ALMOST PERIODICITY AND THE QUANTAL H THEOREM. I.C.Percival.

J. math. Phys. (USA), Vol. 2, No. 2, 235-9 (March-April, 1961).

The H theorem for an ensemble of isolated quantal systems states that the coarse-grained entropy of the ensemble increases to its equilibrium value and stays there. It is proved that the H theorem for an ensemble of isolated quantal systems with a discrete energy spectrum is false provided the systems satisfy certain broad onditions: the theorem is false for bounded many-particle systems with potential interaction, provided that interaction contains no repulsive singularities stronger than r^{-2} and no attractive singularities stronger than r^{-1}. Ensembles of such systems behave almost periodically, in the sense of Bohr. The entropy and the probability of finding an observable in a given range are both almost periodic functions of time.

5217 ON THE DENSITY FIELD DESCRIPTION OF A BOSON SYSTEM. Hong-Mo Chan and J.G.Valatin.

Nuovo Cimento (Italy), Vol. 19, No. 1, 118-30 (Jan. 1, 1961).

The introduction of a density description through a field approach is discussed. Additional mathematical complications resulting from the appearance of powers of the δ-function can be avoided by means of a limiting process. The configuration space argument of Bogolubov and Zubarev is cast in an x-space form in which simple expressions are given. In the resulting representation the normalization integral is defined by means of a weight function the expression of which is determined. The weight function establishes the connection between the rather different expressions of the two density field representations. Some simple cases are considered and a variational principle is formulated.

5218 A NEW APPROACH TO THE MANY BODY PROBLEM, IN PARTICULAR TO THE THEORY OF THE ELECTRON GAS. N.Fukuda.

Suppl. to Physica (Netherlands), Vol. 26, S162-S169 (Dec., 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Corrections to the Gell-Mann, Brueckner and Sawada theory may be made if one transforms to the high-density eigenfunctions. It is shown how the matrix elements of the Hamiltonian can be calculated. D.J.Thouless

QUANTUM MECHANICAL THREE-BODY PROBLEM. See Abstr. 4922

5219 APPLICATIONS OF THE MONTE CARLO METHOD IN STATISTICAL PHYSICS. I.Z.Fisher.

Uspekhi fiz. Nauk (USSR), Vol. 69, No. 3, 349-69 (Nov., 1959). In Russian.

Describes the study of the problem of the imperfect gas or liquid with interactions between molecules of the "hard-sphere" or "Lennard-Jones" types. This problem is replaced by a Markov type problem with discrete states, which is then treated by the Monte-Carlo method, which is described. The results are summarized and compared with those of other theoretical approaches with some experimental results on argon, and with the machine calculations of Alder and Wainwright, (Abstr. 5699 of 1958) based on the molecular dynamics of small assemblies of hard spheres. [English translation in: Soviet Physics—Uspekhi (USA), Vol. 2, No. 6, 783-96 (June, 1960)]. H.N.V.Temperley

5220 THEORY OF THE TWO- AND ONE-DIMENSIONAL RIGID SPHERE FLUIDS.

E.Helfand, H.L.Frisch and J.L.Lebowitz.

J. chem. Phys. (USA), Vol. 34, No. 3, 1037-42 (March, 1961).

The approximate theory of the three-dimensional hard sphere fluid developed by Reiss, Frisch, and Lebowitz has given good predictions with little labour. In an attempt to investigate the reason for this result, in this paper further evidence is adduced for the internal consistency of the approximations of this theory. Thus it is noted that the same equation of state of hard sphere fluid is obtained when one used the "integral condition" as when the "infinity condition" is used. The theory is then applied to the study of the thermodynamic properties, in particular the equation of state, of the rigid sphere fluid in two and one dimensions. The approximate equation of state of the two-dimensional rigid sphere fluid is in good agreement over the range of fluid densities with the results of the results of the machine Monte Carlo calculations by Jacobson and Wood and dynamical calculations of Wainwright and Alder. The exact Tonks' equation of state of the one-dimensional rigid sphere fluid is derived in a particularly simple manner.

5221 GROUND STATE OF A SYSTEM OF INTERACTING BOSONS. N.M.Hugenholtz.

Suppl. to Physica (Netherlands), Vol. 26, S170-S173 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The elimination of operators referring to particles in the condensed phase is discussed. It is shown by a general argument that the excitation spectrum has no gap at zero momentum. D.J.Thouless

5222 RELATIONSHIP BETWEEN SYSTEMS OF IMPENETRABLE BOSONS AND FERMIONS IN ONE DIMENSION.

M.Girardeau.

J. math. Phys. (USA), Vol. 1, No. 6, 516-23 (Nov.-Dec., 1960).

A rigorous one—one correspondence is established between one-dimensional systems of bosons and of spinless fermions. This correspondence holds irrespective of the nature of the interparticle interactions, subject only to the restriction that the interactions have an impenetrable core. It is shown that the Bose and Fermi eigenfunctions are related by $\psi^B = \psi^F A$, where A $(x_1 \cdots x_n)$ is +1 or −1 according as the order pq···r, when the particle coordinates x_j are arranged in the order $x_p < x_q < \cdots < x_r$, is an even or an odd permutation of 1···n. The energy spectra of the two systems are identical, as are all configurational probability distributions, but the momentum distributions are quite different. The general theory is illustrated by application to the special case of impenetrable point particles; the one—one correspondence between bosons with this particular interaction and completely noninteracting fermions leads to a rigorous solution of this many-boson problem.

5223 SOME NONEQUILIBRIUM PROPERTIES OF A BOSE SYSTEM OF HARD SPHERES AT EXTREMELY LOW TEMPERATURES.

Tai Tsun Wu.

J. math. Phys. (USA), Vol. 2, No. 1, 105-23 (Jan.-Feb., 1961).

The pseudopotential method is used to study a special type of flow for a Bose system of hard spheres. In the first-order approximation, the wave-function of the entire system is assumed to be the product of identical single-particle wave-functions, which in general are time-dependent. Such a flow is necessarily irrotational, and the single-particle wave-function satisfies a Schrödinger equation with a nonlinear self-coupling term. On the basis of this equation of motion, the following properties of the Bose system are discussed: the effect of the rigid wall, the moment of inertia, the compressional wave, and a type of "vortex filament". In the second-order approximation, the wave-function of the system is expressed in terms of two functions such that one of them describes the single-particle state suitable for most of the particles while the other one describes the pair excitations. The much more complicated equations of motion are found, but in this approximation the flow is no longer strictly irrotational. The compressional waves are also studied in the second-order approximation.

5224 IMPERFECT BOSE SYSTEM.

C.N.Yang.

Suppl. to Physica (Netherlands), Vol. 26, S49-S57 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Expressions for the ground-state energy of a system of hard-sphere bosons can be obtained in the low-density and close-packing limits. The lowest excited states are phonons in the low-density limit, but they may be similar to the excitations of a Fermi gas in the close-packing limit; higher excited states are also discussed. At low densities there is a phase transition similar to the free boson phase transition; the phase diagram is modified by the addition of an attractive force. Some general properties of boson systems can be deduced from the properties of the density matrix. The two-fluid theory, the existence of second sound, and superfluid properties can be deduced from the low-density theory. D.J.Thouless

5225 BOSE—EINSTEIN SYSTEM WITH ATTRACTIVE FORCES.

K.Huang.

Suppl. to Physica (Netherlands), Vol. 26, S58-S61 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The properties of a system of bosons interacting by means of a short-range repulsion and a long-range attraction are derived by use of a pseudopotential method.

5226 THE RELATION OF THE STATISTICAL VARIATIONAL PRINCIPLE TO THE METHOD OF PARTIAL SUMMATION OF DIAGRAMS IN THERMODYNAMIC PERTURBATION THEORY IN THE MODIFIED FORMULATION OF THE PROBLEM OF A NON-IDEAL BOSE—EINSTEIN SYSTEM.

V.V.Tolmachev.

Dokl. Akad. Nauk SSSR, Vol. 134, No. 6, 1324-7 (Oct. 21, 1960).
In Russian.

The modified problem, in which operators referring to particles in the zero momentum state are replaced by numbers, is treated by using the variational principle together with the canonical quasiparticle transformation. It is shown that identical results can be obtained by summing a certain class of diagrams in perturbation theory. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 5, 984-8 (March-April, 1961)]. D.J.Thouless

5227 CONSTRUCTION OF ASYMPTOTIC EXPANSIONS FOR WEAK INTERACTION FROM A FORMAL THERMODYNAMIC PERTURBATION THEORY WITH A MODIFIED FORMULATION OF THE PROBLEM OF A NON-IDEAL BOSE—EINSTEIN SYSTEM.

V.V.Tolmachev.

Dokl. Akad. Nauk SSSR, Vol. 135, No. 1, 41-4 (Nov. 1, 1960).
In Russian.

Perturbation expansions of thermodynamic quantities are regarded by the author as "asymptotic" if they are valid when the interactions are weak enough. From this point of view a number of expansi are discussed and their range of validity is estimated. [English translation in: Soviet Physics — Doklady (USA)]. R.Eisenschit

5228 TEMPERATURE-DEPENDENT ELEMENTARY EXCITATIONS IN A NON-IDEAL BOSE—EINSTEIN SYSTEM.

V.V.Tolmachev.

Dokl. Akad. Nauk. SSSR, Vol. 135, No. 4, 825-8 (Dec. 1, 1960).
In Russian.

Green's functions for this system are defined, and their unperturbed values found. A secular equation is written down whose roots give the energies of excited states at any temperature below the critical temperature. Approximate solutions of this dispersion formula are discussed, and it is suggested that the spectrum has two branches, but this conclusion is withdrawn in a note added in proof. [English translation in: Soviet Physics — Doklady (USA)]. D.J.Thoule

5229 THERMODYNAMICAL VARIABLES IN TERMS OF DISTRIBUTION FUNCTIONS OF QUASI-PARTICLES.

C.De Dominicis.

Suppl. to Physica (Netherlands), Vol. 26, S94-S101 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht 1960 (see Abstr. 1707 of 1961). Perturbation series expansions fo thermodynamic functions of a system of interacting fermions can b rewritten in terms of distribution functions of quasi-particles. Th method makes the transition to zero temperature simpler. The rea quasi-particle energy introduced is not to be identified with the complex energy of physical quasi-particles and has no direct physical interpretation. The derivation of the theory is outlined. D.J.Thoule

5230 ON THE THEORY OF IMPERFECT FERMI GASES.

C.Bloch.

Suppl. to Physica (Netherlands), Vol. 26, S62-S74 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrech 1960 (see Abstr. 1707 of 1961). Various forms of the perturbation expa sion of the Gibbs potential are described. The time-dependent, time-independent and Fourier expansions are compared. The difference b ween the zero temperature limit of this theory and ground-state pertur bation theory is explained. The expansion can be expressed in terms o irreducible diagrams, and the disentanglement theorem used to get this result is discussed. D.J.Thoules

5231 RELATIONS INVOLVING THE FORWARD SCATTERIN AMPLITUDE IN A FERMI GAS.

B.A.Jacobsohn.

Suppl. to Physica (Netherlands), Vol. 26, S78-S80 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Some relations between single-particle energy levels and forward scattering amplitudes are summarized. D.J.Thoules

5232 COLLECTIVE EXCITATIONS IN FERMI SYSTEMS.

V.M.Galitsky.

Suppl. to Physica (Netherlands), Vol. 26, S174-S180 (Dec. 26, 1960)

International Conference on Many-Particle Problems, Utrecht 1960 (see Abstr. 1707 of 1961). In addition to scattering states of two quasi-particles in a Fermi gas, there may be bound states, collective excitations, which can be studied by means of two-particle Green's functions. It is shown that for repulsive interactions, the Green's functions have poles at the plasma frequency fo Coulomb repulsion, or at the frequency of zero sound for short-range repulsion. The mean free path is too long for ordinary soun to propagate. For attractive forces the Bose condensation of pairs must be taken into account, and the graphs giving the Green's functions are more complicated. Ordinary sound is possible in neutral systems, and nonspherical excitations can occur. For charged particles, plasma waves are again obtained. D.J.Thoules

5233 TWO REMARKS ON THE THEORY OF THE FERMI GAS. L.Van Hove.
Suppl. to Physica (Netherlands), Vol. 26, S200-S203 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). It is argued that a sharp Fermi surface may be impossible even if the interaction is repulsive. An example is worked out in which the unlinked cluster expansion has an infinite radius of convergence, while the linked cluster expansion has a finite radius of convergence. D.J.Thouless

5234 EXTENSION OF DIAGRAM TECHNIQUE OF FIELD THEORY TO FERMI SYSTEMS WITH PAIRING PHENOMENON (WITH APPLICATION TO SPHERICAL NUCLEI). S.T.Beliaev.
Suppl. to Physica (Netherlands), Vol. 26, S181-S187 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The structure of one-particle Green's functions for fermions interacting by an attractive force is displayed, and it is shown how quasi-particle energies may be obtained from them. The two-particle Green's functions are analysed, and the equations for them are solved in a simplified model. Energy levels are obtained which are, in general, mixtures of particle—hole, particle—particle and hole—hole excited states. D.J.Thouless

5235 FLOW PROPERTIES OF SUPERFLUID SYSTEMS OF FERMIONS. A.E.Glassgold and A.M.Sessler.
Nuovo Cimento (Italy), Vol. 19, No. 4, 723-37 (Feb. 16, 1961).

The nonspherically symmetric solutions to the Bardeen—Cooper-Schrieffer theory are given a physical interpretation in terms of an anisotropic fluid model. These solutions have been used previously to predict a phase transition in liquid He^3 by Emery and Sessler and by Brueckner, Soda, Anderson and Morel. An investigation of the flow properties of such systems is made that involves the calculation of the effective mass for flow in a straight channel and the moment of inertia of a cylindrical container of the liquid. The angular dependent energy gap characteristic of this type of theory leads to an effective mass for flow that depends on the angle between the axis of symmetry of the fluid and the direction of flow. The effective mass for flow vanishes as the absolute temperature tends to zero, although not as rapidly as for a spherically symmetric gap. The moment of inertia, when the symmetry direction for the fluid and the rotation axis are the same, is simply related to the mass for flow.

5236 APPLICATION OF THE QUANTUM FIELD THEORY METHODS IN INVESTIGATION OF THE THERMODYNAMICAL PROPERTIES OF AN ELECTRON AND PHOTON GAS. I.A.Akhiezer and S.V.Peletminskii.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1829-39 (June, 1960).
In Russian.

The thermodynamic potential of an electron, positron and photon gas is determined by field-theory methods with an allowance for the interaction between particles to an accuracy of terms proportional to $e^4 \ln e^2$. Divergences which appear in the high momentum region of the virtual particles are removed by renormalizing the electron charge and mass and by redetermination of the vacuum level. General expressions are derived which take into account relativistic effects, and asymptotic formulae are derived for the exchange and correlational energies. Corrections to the black-body radiation energy due to interaction between photons and electron—positron pairs are obtained. [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1316-22 (Dec., 1960)].

5237 DIFFUSION OF RADIATION IN A MEDIUM WITH A SPECULARLY REFLECTING BOUNDARY. V.V.Sobolev.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 3, 571-4 (Jan. 21, 1961).
In Russian.

Continuation of previous work (Abstr. 4963 of 1960) on the reradiation and absorption coefficients in a semi-infinite annular medium bounded by a mirror surface; this time the coefficient of reflection on this surface depends on the angle of incidence. The results can be applied to the diffusion of a spectral line when passing through an expanding planetary nebula or an envelope of a new star, where the Doppler effect affects the reflection of quanta on the moving boundary of the envelope. [English translation in: Soviet Physics—Doklady (USA)]. J.K.Skwirzynski

GENERAL MECHANICS

5238 CONTACT PROBLEM FOR AN ELASTIC LAYER UNDER THE ACTION OF AN ECCENTRIC VERTICAL FORCE ON A CIRCULAR RIGID PUNCH. K.E.Egorov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 781-4 (Aug. 1, 1960).
In Russian.

For abstract, see Abstr. 19011 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 890-4 (Jan.-Feb., 1961)].

5239 THE ELASTIC DEFORMATION OF CONVEX SHELLS IN THE CRITICAL REGION. A.V.Pogorelev.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 785-7 (Aug. 1, 1960).
In Russian.

For abstract, see Abstr. 19012 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 895-900 (Jan.-Feb., 1961)].

5240 SCHWARTZ'S ALGORITHM IN STRESS PROBLEMS OF THE THEORY OF ELASTICITY. E.N.Nikol'skii.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 549-52 (Nov. 21, 1960).
In Russian.

Schwartz's algorithm allows the determination of stress and strain conditions in a domain D_{12} which is common to (is the intersection of) two domains D_1 and D_2, in terms of these conditions in the latter two domains. The problem is formulated in terms of boundary conditions on the boundaries of D_{12} and D_1, and of D_{12} and D_2 and is solved by minimizing the deformation energy integral. [English translation in: Soviet Physics—Doklady (USA)]. J.K.Skwirzynski

5241 A NEW THEOREM FOR MOMENT OF INERTIA. S.N.Srivastava.
Amer. J. Phys., Vol. 29, No. 3, 211 (March, 1961).

The theorem is stated as "The moment of inertia of a body about an axis is equal to the sum of the moment of inertia of the same body about the same axis, when the mass of the body is projected over two mutually perpendicular planes, each containing the axis of rotation". [It is an alternative to the "slab and rod theorem"]. E.G.Knowles

5242 SOLUTION BY MEANS OF AN ELECTRONIC DIFFERENTIAL ANALYSER OF THE EQUATION OF MOTION OF AN ELASTIC PENDULUM WITH TWO DEGREES OF FREEDOM. J. González Ibeas, V.Aleixandre Campos and J.M.Ruiz Gonzalvo.
Rev. Cienc. apl. (Spain), Vol. 14, No. 5, 412-21 (Sept.-Oct., 1960).
In Spanish.

The equations contain terms proportional to velocity, spring forces and gravity. Block diagrams of an electronic simulator are given and the method of operation is discussed. The case of a flexible rubber suspension is dealt with by inserting gates to make the spring force voltage zero when the rubber bends after returning to its unloaded length. Equivalents for the coefficients in the mechanical and electrical systems are obtained from which the parameters of the simulator can be determined, with a change of time scale. A solution to a particular problem is obtained from the analyser and is found to be in agreement with a numerical solution. W.G.Stripp

5243 MOTION OF GYROSCOPIC COMPASS UNDER THE INFLUENCE OF ORDINARY FORCES. Ya.N.Roitenberg.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 5, 1045-8 (Aug. 11, 1960).
In Russian.

For abstract, see Abstr. 19034 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 718-22 (Jan.-Feb., (1961)].

EXPERIMENTS ON THE ANGULAR MOMENTUM OF A SUPERCURRENT AND THE POSSIBILITY OF A SUPERCURRENT GYROSCOPE. See Abstr.5401

5244 THE STABILITY OF FORCED OSCILLATIONS IN A SELF-ROTATING SYSTEM. M.Ya.Kushul'.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 4, 787-90 (Feb. 1, 1961).
In Russian.

Self-rotating system is one which is potentially self-starting and which can oscillate in two directions. The system discussed is non-autonomous (with oscillatory impressed forces) and nonlinear (due to the decrease of friction with the amplitude of rotation and due to the dependence of the curvature of axes of rotation on the displacement). A typical example is a turbine rotor whose velocity of rotation is between the critical values of the first and the second kind. Application of the perturbation to the linear periodic solution shows that the region of harmonic motion has two ranges of instability, depending on the frequency of impressed forces. In the first range the instability is caused by internal friction and in the second by external friction. [English translation in: Soviet Physics—Doklady (USA)]. J.K.Skwirzynski

MECHANICAL MEASUREMENTS

5245 MEASUREMENT OF THICKNESS OF THIN TRANSPARENT FILMS USING FLUORESCENCE.
B.P.Bunt.
Brit. J. appl. Phys., Vol. 12, No. 4, 175-7 (April, 1961).

A molecular fluorescence method of comparing the thickness of transparent films (in the range 3×10^{-6} to 10^{-2} cm) is described. An instrument for use in the middle of this range (10^{-4} cm) is also described and results show that its accuracy is to better than ±2%.

5246 TECHNIQUE USING ^{85}Kr-LABELLED KRYPTON FOR SURFACE AREA MEASUREMENTS.
D.W.Aylmore and W.B.Jepson.
J. sci. Instrum. (GB), Vol. 38, No. 4, 156-9 (April, 1961).

A simple volumetric apparatus for the determination of the surface area of solid materials is described. Isotopically labelled krypton (Kr^{85}) is used as the adsorbate and the pressure measured using a combined counting cell and Geiger—Müller tube. The apparatus can be used to measure areas of 0.01 m^2 to 1 m^2 with a precision to 5% for 0.025 m^2, 1% for 0.1 m^2 and 1.5% for 1 m^2.

MEASUREMENT OF THE DENSITY IN A VAPOUR STREAM. See Abstr. 5104

5247 APPARATUS DRAWINGS PROJECT. REPORT NUMBER 15. ACCELERATION CARTS AND TRACK.
R.G.Marcley.
Amer. J. Phys., Vol. 29, No. 5, 294-7 (May, 1961).

A simple and well-tested design for acceleration carts is described. The size of the apparatus will permit its use in the largest lecture rooms with excellent visibility. The equipment is sturdy and adaptable, but will provide data reproducible to within a fraction of 1%. The materials used and the machining procedures required are conventional. Several accessories are also described.

5248 MEASUREMENT OF PRESSURES FROM 0,1 TO 5 mm Hg BY A THERMOCOUPLE MANOMETER [TYPE LT-2]. A.M.Grigor'ev, L.P.Khavkin and N.V.Tsȳbina.
Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 97-9 (May-June). In Russian.

A description is given of this manometer, together with a system for identification of its calibration characteristics when operated at constant temperature. Recommendations are made for a simple alteration of the VT-2 vacuum gauge which makes possible its use with the LT-2 manometer at constant temperature. Theoretical considerations are given which make it possible to predict the behaviour of the manometer when pressures in different gases are measured, and experimental verification is provided. [English translation in: Instrum. exper. Tech. (USA), No. 3, 427-30 (May-June, 1958; publ. June, 1959)].

5249 OPTICAL METHODS FOR THE MEASUREMENT OF THE HEIGHT OF A MERCURY COLUMN IN A MANOMETER: A NEW INTERFERENCE MANOMETER. J.Terrien.
Rev. Opt. (France), Vol. 38, No. 1, 29-37 (Jan., 1959). In French.

Several interferometric methods are described which enable one to measure differential changes in the relative heights of two menisci of a mercury column. R.A.Weale

MECHANICS OF FLUIDS

(See also Magnetohydrodynamics)

5250 ON THE VISCOSITY OF LIQUIDS.
A.Carrelli and F.Porreca.
Nuovo Cimento (Italy), Vol. 19, No. 2, 197-209 (Jan. 16, 1961).

Describes an experimental method allowing the determination of an imaginary part, if it exists, in the viscosity coefficient. Work which was carried out using a particular phasemeter, permitted this imaginary part to be measured; in some liquids it was found to be considerable.

5251 INERTIA EFFECTS IN VISCOUS FLOWS.
J.L.Livesey.
Internat. J. mech. Sci. (GB), Vol. 1, No. 1, 84-8 (Jan., 1960).

Certain well-known formulae in viscous flow neglect the inertia terms in the equation of motion. A method for including the inertia effects by solving the equation of motion approximately, in its integral form, is demonstrated with reference to the particular problem of radial flow between parallel plates. It is shown that the significance of the inertia effects may readily be estimated.

5252 AN EXPERIMENTAL INVESTIGATION OF INERTIA EFFECTS IN VISCOUS FLOW.
P G.Morgan and A.Saunders.
Internat. J. mech. Sci. (GB), Vol. 2, No. 1-2, 8-12 (Oct., 1960).

See preceding abstract. Experiments are presented concerning the importance of the inertia term in the Navier—Stokes equation for viscous radial flow between parallel plates.

5253 MECHANICAL MOMENTUM OF SOLUTIONS OF LIQUIDS IN A ROTATING ELECTRIC FIELD.
E.Grossetti.
Nuovo Cimento (Italy), Vol. 19, No. 1, 1-5 (Jan. 1, 1961).

For previous work, see Abstr. 4336 of 1959. The rotational mechanical momenta were determined for solutions of polar liquids in non-polar ones, and solutions of two polar liquids, with relation to the variation of the concentration, in electric fields rotating at very high frequency (100 Mc/s). For some solutions the behaviour of the mechanical momenta is that of a constant decrease at the variation of the concentration, while for others a maximum is note in the behaviour of the momenta at a concentration which correspo nearly always, to about 70% of the polar liquid.

5254 UPSTREAM DIFFUSION IN HAGEN—POISEUILLE FLO
T.O.Passell and C.L.Perry.
Phys. of Fluids (USA), Vol. 4, No. 4, 444-7 (April, 1961).

A theoretical study is described for steady state diffusion of a contamination from a large reservoir of static fluid into a cylindrical tube discharging fluid into the reservoir. Contaminant decay is considered. Numerical results are presented for the rate of decrease along the tube of the concentration of contaminant for Reynolds × Schmidt numbers > 10 and either small or zero decay. The method used explicitly exhibits quantities of physical interest including a simple form for the asymptotic solution. These results are of practical use in estimating the contamination in the tube at points that are relatively close to the mouth of the tube. An estimate is made of the distance from the tube mouth at which the asymptotic solution given becomes valid. Used for the prediction of heat flow, the results are valid for Péclet numbers > 10.

5255 THERMAL EXCHANGE FOR NON-NEWTONIAN FLUID IN LAMINAR MOTION IN CIRCULAR TUBES. I(1). THERMAL EXCHANGE FOR CONSTANT WALL TEMPERATURE. M.Dente.
R.C. Accad. Naz. Lincei (Italy), Vol. 29, No. 1-2, 52-61 (July-Aug., 1960). In Italian.

The Gräetz—Nusselt problem for fluids in which the resistive force is of the form $-K(\partial v/\partial t)^{n'}$ is considered, and solutions are obtained for various values of the exponent n' subject to the condition that the temperature at the wall of the tube is maintained con stant. S.Weintrou

5256 THERMAL EXCHANGE FOR NON-NEWTONIAN FLUIDS IN LAMINAR MOTION IN CIRCULAR TUBES. I(2). THERMAL EXCHANGE FOR CONSTANT WALL TEMPERATURE. M.Dente.
R.C. Accad. Naz. Lincei (Italy), Vol. 29, No. 3-4, 186-92 (Sept.-Oct., 1960). In Italian.

Continuation of the work of Pt I(1) (see preceding abstract). S.Weintrou

5281 LIQUID FLOW IN TUBES. IV. THE TRANSITION PROCESS AND TURBULENT FLOW RELATED TO TUBE DIAMETER AND MICROSCOPIC SURFACE PROPERTIES.
E.R.Lindgren.

Ark. Fys. (Sweden), Vol. 18, Paper 33, 449-64 (1960).

Studies previously reported (see Abstr. 8621-3 of 1960) on the transition process were carried further by variation of tube diameter and surface finish. The experiments indicate the influence of tube diameter and microscopic surface roughness on certain transition quantities. Thus, the transition Reynolds number, R' (= the lowest Reynolds number at which self-preserving turbulent slugs ever appear), increased from about 1800 to 2200 (~ 20% increase) when the tube diameter increased from about 4 mm to 24 mm (~ 600% increase). A change of the microscopic surface roughness by sand-blasting of the tubes did not influence the R' values nor the relative rear velocity of the turbulent slugs. However, it did increase their relative front velocity and also decreased the critical Reynolds number, R_k(= the Reynolds number at which the turbulent slugs begin to split or expand during their downstream travel). Hence, in considering present and previous experimental findings, it seems that the transition process and turbulence maintenance mechanism involve a complicated pattern of factors which at present cannot be separated from one another.

5258 LIQUID FLOW IN TUBES. V. EFFECTS OF LATERAL TUBE DEFLECTIONS ON SOME TURBULENT TRANSITION QUANTITIES. E.R.Lindgren.

Ark. Fys. (Sweden), Vol. 18, Paper 37, 533-41 (1960).

Previous investigations (see preceding abstract) on the transition pattern for tube flow of liquids have shown that both structural properties of the liquids as well as microscopic mechanical properties of the tube walls may influence several characteristics of the appearance and development of turbulent slugs. The present observations further indicate that rather slight lateral tube deflections may influence the transition pattern, causing the burst and development of turbulent slugs in primarily undisturbed laminar flow at higher Reynolds numbers, while simultaneously a distinct damping effect is noted on the rate of development of already existing turbulent streaks when compared with their rate of extension in straight tube flow. Furthermore, within the region of transition at lower Reynolds numbers, the damping effect may dominate over the self-preserving turbulence mechanism to such an extent that turbulent slugs developed in a straight part of the tube may be damped out completely in a following curved part of it. The findings seem to complete observations on flow through helical tubes reported by White (1929) and Taylor (1929).

5259 EXISTENCE OF APERIODIC FLOW WITH FREE BOUNDARY. Yu.P.Krasovskii.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 768-70 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 19050 of 1960. [English translation in: Soviet Physics — Doklady (USA), Vol. 5, No. 4, 684-6 (Jan.-Feb., 1961)].

5260 THE CAUCHY [AND] POISSON PROBLEM FOR WAVES OF FINITE AMPLITUDE.
L.N.Sretenskii and Ya.I.Sekerzh-Zen'kovich.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 544-5 (July 21, 1960). In Russian.

For abstract, see Abstr. 19078 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 677-8 (Jan.-Feb., 1961)].

5261 GENERATION OF WATER WAVES BY THE WIND. B.L.Hicks.

Nature (GB), Vol. 188, 1016-17 (Dec. 17, 1960).

Analyses data on variation of spectral energy density of small deep-water waves with wind-speed and fetch. The results indicate existence of a saturated spectrum at frequencies above a critical value, with spectral density almost independent of speed and fetch, and decreasing roughly as f^{-5} (f is the frequency), indicating presence of gravity waves. The author raises the question of whether large-scale waves in ocean will show a similar saturation effect. N.Curle

5262 STABILIZATION OF TAYLOR INSTABILITY BY A SHEARING FLOW. S.Feldman.

Phys. of Fluids (USA), Vol. 4, No. 3, 385-6 (March, 1961).

With Reynolds number R, based on characteristics of the heavier (and uppermost) of two fluids, flow is unstable to disturbances of small wave-number when R = 0, but stable at moderate R. The author conjectures that a liquid film (R = 0) could be stabilized by blowing to induce shearing, and verifies this experimentally for a flat plate with wetted undersurface. N.Curle

SPARK-INDUCED SHOCK WAVES IN WATER. See Abstr. 5430

5263 A RECORDING FLOWMETER USING A RADIOACTIVE FLOAT. D.W.Tims.

J. sci. Instrum. (GB), Vol. 38, No. 4, 145-9 (April, 1961).

An instrument of the type comprising a float in a vertical tapered tube is often suitable for measuring low rates of fluid flow, but difficulties arise in obtaining remote indication, recording or control owing to the small physical size of the float and the consequent failure of conventional methods of detecting its position. This paper describes a method in which a radioactivated float and low-voltage, high-current Geiger tubes are used to overcome these difficulties.

5264 ELECTROLYTIC TANK FOR STUDYING THE FLOW OF LIQUIDS THROUGH TUBES OF VARIOUS CROSS SECTIONS. M.J.Denton and S.G.Lipson.

J. sci. Instrum. (GB), Vol. 38, No. 4, 150-2 (April, 1961).

Analogue methods of solving the Poisson equation in two dimensions are discussed briefly. The electrolytic tank equivalent must have a uniform current source density; an approximation to this is achieved by introducing equal currents through conductors spaced in a square lattice. As examples, the flow velocity distribution in a tube of rhombic cross-section is shown, and the equivalent radii for rhombic tubes of various angles are found.

5265 THE EFFECT OF SULPHUR ON THE SURFACE PROPERTIES AND STRUCTURE OF NICKEL—CARBON ALLOYS. R.A.Sidorenko and B.V.Tsarevskii.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 866-72 (Dec., 1960). In Russian.

The sessile-drop method was used to study the surface tension and measure the contact angle of molten Ni—C—S alloys on a graphite substrate. Sulphur reduced the contact angle and the surface tension of Ni—C alloys at the surfaces in contact with air and with graphite. The conversion of graphite from spherical to laminar form was due to selective adsorption of sulphur on the graphite crystal plane (0001). A.Tybulewicz

LIQUID STATE

(Liquid helium is included under Low-Temperature Physics)

5266 STRUCTURE OF ALKALI METALS IN THE LIQUID STATE. N.S.Gingrich and L.Heaton.

J. chem. Phys. (USA), Vol. 34, No. 3, 873-8 (March, 1961).

Neutron diffraction patterns were obtained for the alkali metal liquids; lithium (180° C), sodium (100° C), potassium (65° C), rubidium (40° C, 160° C, 160° C, 240° C, and 360° C), and caesium (30° C, 300° C, and 575° C). It was found necessary to correct intensities for scattering by a free atom for lithium and sodium but not for the heavier atoms. Atomic distribution curves were computed for all the above cases, and compared with results from X-ray diffraction. Just above melting temperatures the nearest-neighbour distances are for lithium 3.15 A, sodium 3.82 A, potassium 4.64 A, rubidium 4.97 A, and caesium 5.31 A, the number of nearest neighbours is, within one-half atom, about 9.0 to 9.5 atoms in each case. At elevated temperatures with rubidium and caesium, a weak subsidiary concentration of atoms appears between the usual first and second neighbour concentration.

5267 DIFFRACTION OF X-RAYS BY SOME LIQUID MIXTURES. E.Tartaglione.

Nuovo Cimento (Italy), Vol. 18, No. 6, 1072-5 (Dec. 16, 1960).

Intensity measurements are reported of the diffraction of X-rays by mixtures of polar and non-polar liquids which present some remarkable anomalies in the mechanical momentum generated in a rotating electric field. The results give evidence of the presence of particular molecular associations in the zone in which the anomalies in the mechanical momentum are noted.

5268 A MORE PRECISE FORM OF THE SUPERPOSITION APPROXIMATION IN THE THEORY OF LIQUIDS.

I.Z.Fisher and B.L.Kopeliovich.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 81-3 (July 1, 1960). In Russian.

For abstract, see Abstr. 19091 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 761-3 (Jan.-Feb., 1961)].

5269 A CELL-CLUSTER THEORY FOR THE LIQUID STATE. VI. BINARY LIQUID SOLUTIONS AND HOLE THEORY.

J.S.Dahler and E.G.D.Cohen.
Physica (Netherlands), Vol. 26, No. 2, 81-102 (Feb., 1960).

For Pt V, see Abstr. 8647 of 1960. The formal cell-cluster theory for a binary liquid solution is given. The configurational partition function is expanded in terms of cluster integrals which are small if the molecules are mainly confined to the lattice sites of a virtual lattice system. The evaluation of the partition function is performed in the quasi-chemical as well as in the Bragg—Williams approximation. The methods used are very similar to those employed by Guggenheim in his studies on polymer solutions. When only single cells are taken into account a generalization of the partition function used by Prigogine and his co-workers is obtained. The corrections due to the introduction of clusters of two cells are given and applied to a few simple cases. The same formalism can be used to construct the cell-cluster theory for a liquid with a fixed number of holes. The necessary modifications are indicated and the results given for the case that only clusters of one and two cells are considered. As an example a one dimensional ideal gas with holes is treated.

5270 GEOMETRIC BASIS OF PHASE CHANGE.

R.Ginell.
J. chem. Phys. (USA), Vol. 34, No. 3, 992-8 (March, 1961).

A consideration of the higher j-mers by association theory shows that starting with the 7-mer and going up to 19-mer, spherically symmetric atoms can pack in an unsymmetrical arrangement in which more bonds exist among the atoms in the array than if the atoms were packed symmetrically. The asymmetric pattern is then the model for the liquid while the symmetric array yields the crystal. The transition from the liquid to the crystal is difficult by homogeneous nucleation because it requires a co-operative effort of, in the neighbourhood of 12-15 atoms. Heterogeneous nucleation is, however, simple since by this mechanism the region where the liquid j-mers are more stable than the crystal j-mers is bypassed. Methods of calculating the equilibrium constants and the concentrations of the various species are derived from association theory. The critical value where the formation of higher close-packed j-mers becomes important is when the value of the equilibrium constant exceeds 1.

5271 NEUTRON SCATTERING FROM A LIQUID ON A JUMP DIFFUSION MODEL.

C.T.Chudley and R.J.Elliott.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 353-61 (Feb., 1961).

The incoherent inelastic scattering cross-section of slow neutrons from liquids is calculated using a simple model in which the liquid is assumed to have appreciable short-range order in a quasi-crystalline form. Diffusive motion takes place in large discrete jumps, between which the atoms oscillate as in a solid. The model predicts a definite, easily calculable cross-section which is not dominated by diffusion effects as when continuous diffusion is assumed, but shows a characteristic variation with angle which could be looked for experimentally. The related pair correlation functions are dominated at small r and t by vibrational effects. Although simple and extreme the model explains several aspects of the observations of Brockhouse and Pope (Abstr. 937 of 1960) and others. A brief discussion of the coherent scattering cross-sections for the model is given although explicit formulae are not obtained.

5272 KINETICS OF CRYSTAL NUCLEATION IN SOME NORMAL ALKANE LIQUIDS.

D.Turnbull and R.L.Cormia.
J. chem. Phys. (USA), Vol. 34, No. 3, 820-31 (March, 1961).

The crystal nucleation behaviour of some normal alkane liquids — $C_{15}H_{34}$, $C_{17}H_{36}$, $C_{18}H_{38}$, $C_{24}H_{50}$, and $C_{32}H_{66}$ — was investigated by the droplet technique. The relative undercoolings, $1 - \lambda$, (i.e. the actual undercooling in units of the absolute melting temperature) at which the crystal nucleation frequency in these liquids becomes c 10^7 cm^{-3} sec^{-1}, are 0.037 to 0.043, and almost an order of magnitude smaller than those for simple molecular substances. Crystal nucleation frequencies in droplets of $C_{17}H_{36}$ and $C_{18}H_{38}$ samples of very high purity were determined quantitatively. The frequencies were proportional to droplet volume and increased by a factor of 5000 to 8000 per 1 deg decrease in temperature. The results are satisfactorily described by the classical nucleation theory with values of the crystal nucleus—liquid interfacial tension σ, 7.2 erg cm^{-2} for $C_{17}H_{36}$ and 9.6 erg cm^{-2} for $C_{18}H_{38}$. The experimental pre-exponential factors in the nucleation expression agree with the theoretical values to well within the experimental uncertainty. The small relative undercooling and the weak glass-forming tendency in the high-molecular weight n-alkane liquids is satisfactorily explained by the hypothesis of nucleation of small segments of molecules.

5273 SELF-DIFFUSION IN LINEAR DIMETHYLSILOXANES.

D.W.McCall, E.W.Anderson and C.M.Huggins.
J. chem. Phys. (USA), Vol. 34, No. 3, 804-8 (March, 1961).

The pressure and temperature dependences of the self-diffusion coefficients of the linear dimethylsiloxanes, containing from two to nine silicon atoms were determined by the n.m.r. spin-echo technique. Activation energies and volumes are presented as derived quantities; the constant-volume activation energy is estimated from these data. Extensive comparisons between the diffusion properties of the dimethylsiloxanes and equivalent hydrocarbons are made. From these comparisons, it is concluded that diffusion in siloxanes is controlled to a much larger extent by chain configurational effects. This concept is formalized by expressing the chain-size effects in an entropy of activation model.

5274 HIGH-SPEED COMPUTATIONS IN DIFFUSION KINETICS. III. SOLUTE DEPLETION IN THE CYLINDRICAL ONE RADICAL—ONE SOLUTE MODEL.

H.Fricke and D.L.Phillips.
J. chem. Phys. (USA), Vol. 34, No. 3, 905-8 (March, 1961).

An earlier study (Abstr. 910 of 1959) of the kinetic properties of a cylindrically symmetric one radical—one solute model is extended by taking account of the transient dilution of the solute which occurs during the reaction. The results of the computations are collected in a table from which, by interpolation I_R the fraction of radicals recombining, can be obtained for any experimentally important values of the four dimensionless parameters which define the problem. Under conditions of practical interest the effect of solute depletion on I_R is (a) appreciable only when the ratio of the rate constants of radical—solute and radical—radical reactions is above 0.1, and (b) only slightly affected by the diffusion coefficient of the solute. The role played by solute depletion is elucidated by graphs representing the transient course of the reactions.

UPSTREAM DIFFUSION IN HAGEN—POISEUILLE FLOW.
See Abstr. 5254

5275 CATION—ELECTRON INTERACTION IN METAL—AMMONIA SOLUTIONS.

J.Jortner.
J. chem. Phys. (USA), Vol. 34, No. 2, 678-81 (Feb., 1961).

The problem of electron binding in the field of a cation in metal solutions is treated on the basis of an interstitial ion model. The energy levels and charge distribution of the unpaired electron are computed by a self-consistent field treatment for electron binding in a continuous dielectric medium employing one parameter wave-function. Comparison with experimental results and with theoretical treatment based on a molecular model is presented. The adequacy of the continuous model is discussed.

5276 THE VELOCITY OF ULTRASOUND IN MOLTEN BINARY EUTECTIC METAL SYSTEMS AND ELASTIC PROPERTIES OF SUCH SYSTEMS.

Z.L.Khodov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 772-9 (Nov., 1960). In Russian.

Reports measurements of the composition dependence of the velocity of ultrasound and the adiabatic compressibility in the following molten alloys: Sn—Pb, Sn—Bi, Sn—Cd, Pb—Bi, Pb—Cd, and Bi—Cd. The results are related to short-range order in these liquids.
A.Tybulewicz

5277 ULTRASONIC AND VISCO-ELASTIC RELAXATION IN A LUBRICATING OIL.

N.Ş.Taşköprülü, A.J.Barlow and J.Lamb.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 278-85 (March, 1961).

The velocity of propagation and the absorption of longitudinal waves was measured in a hydrocarbon oil for which the shear modulus together with the spectrum of shear relaxation times has been determined previously. A volume viscosity was found which was approximately equal to the shear viscosity and the results are surprisingly similar to those found by Litovitz and his co-workers for associated liquids. Structural relaxation appears to play an equally important part in determining the second viscosity of the hydrocarbon oil as it does in associated liquids. The effects of association were found to give slightly higher values for the limiting moduli at high frequencies (the instantaneous moduli) and were also responsible for the marked temperature dependence of these moduli. In the present case the relaxing part K_2 of the modulus of compression and the limiting value of the shear modulus were each sensibly independent of temperature. It also appears that for the liquids studied so far $K_2 \cong \frac{4}{3} \cdot G_\infty$. The spectrum of compressional relaxation times was determined and good agreement was found be-ween the measured values of the components of the complex compression modulus and the curves recalculated from the spectrum. The absorption at frequencies above the main part of the dispersion region is governed not by a hysteresis type of loss, as found in associated liquids, but by a residual high-frequency contribution to (α/f^2) due to the (unrelaxed) contribution of the vibrational specific heat relaxation.

5278 INTERFERENTIAL REFRACTOMETRY OF SOLUTIONS.
J.M.Vidal and V.Gandía.

An. Real Soc. Espan. Fís. Quim. (Spain), Vol. 55A, No. 11-12, 43-54 (Nov.-Dec., 1959). In Spanish.

An interferential method was used to measure refractive indices of sulphuric acid solutions of 0-98% by weight of sulphuric acid for even values of that percentage. Additional attachments of the Haber—Loewe interferometer used are described, and results are given. The values thus obtained, together with density values for the same solutions, are used to compute specific partial and molar partial refractions of both constituents of the system. Using the same density values and a similar method, values for the specific partial volumes of solute and solvent are computed and the results are compared with those of the specific partial refractions.

5279 ON LUMINESCENCE DECAY TIMES AND THEIR RELATION TO MECHANISMS OF ENERGY TRANSFER IN RADIATION CHEMISTRY OF LIQUIDS.
M.Burton and H.Dreeskamp.

Disc. Faraday Soc. (GB), No. 27, 64-73 (1959).

"Energy transfer" Discussion, Nottingham, 1959 (see Abstr. 4920 of 1961). Luminescence against time curves, obtained by a newly developed technique, are given. Decay times of luminescence processes in mixed cyclohexane + benzene scintillator systems (with air present) lie in the range around 2 × 10^{-9} sec. Addition of benzene to a cyclohexane solution of p-terphenyl causes a sharp rise in the decay time to a maximum at low benzene concentrations. The decay time is attributed tentatively to the energy transfer process from the lowest excited state. The estimated fraction of such low excited states transferring excitation to the scintillator is only 0.04 to 0.08. On the other hand, the scintillator appears also to quench the excited solvent. With the preliminary data at hand, the luminescence decay times are used as a tool for interpretation of the mechanism of protection in radiolysis of mixed liquid systems.

5280 THE EFFECT OF THE ELECTRIC FIELD INTENSITY ON THE PHOTOCONDUCTIVITY OF LIQUID ORGANIC SYSTEMS.
P.K.Mitskevich and V.G.Bobȳl.

Izv. Akad. Nauk SSSR, Ser. fiz.,Vol. 24, No. 2, 232-6; Disc. 242-5 (1960). In Russian.

"1958 Moscow Dielectrics Conference" (see Abstr. 16003 of 1960). Reports that the dark and photocurrents (produced by ultraviolet illumination) of ionic liquid semiconductors in the form of bromoform, iodoform, propyl bromide, ethyl iodide, bromphenol and other liquids (dissolved in ether, anisole and other solvents) obeyed Ohm's law in weak fields. A.Tybulewicz

5281 EFFECT OF SOLVENT AND SOLUTE STRUCTURE ON SCINTILLATOR PULSE HEIGHTS. II. CORRELATION OF PULSE HEIGHTS FOR AROMATIC LIQUID ORGANIC SCINTILLATORS WITH HAMMETT SUBSTITUENT CONSTANTS.
S.R.Sandler and S.Loshaek.

J. chem. Phys. (USA), Vol. 34, No. 2, 445-7 (Feb., 1961).

It has been found that numerous data in the literature on aromatic organic liquid scintillators could be interpreted in terms of the resonance and polarity of the constituent solvents and fluors. The resonance and polarity of the ring substituted aromatic compounds were characterized quantitatively by Hammett substituent constants (σ). For a number of liquid scintillator systems in which the fluor composition was kept constant and the structure of the aromatic solvent was varied, pulse heights increased approximately linearly with increasing electron donating (negative σ values) power of the substituents on the aromatic molecule. This correlation held for nine different fluors in each of seven different aromatic solvents. A similar correlation was found for a series of fluors consisting of substituted 2,5-diphenyl-1, 3, 4-oxadiazoles and 2, 5-diphenyl 1,3-oxazoles in which toluene was used as the sole solvent. Pulse heights varied much more with a change in substituent groups on the solvent than with a similar change in the fluors. The observed correlation affords a means of organizing a large body of data and of gaining a further insight into the mechanism of scintillation.

5282 SCATTERING OF LIGHT IN SOLUTIONS OF QUININE SULPHATE.
M.Giurgea, C.Ghiţă and M.Musa.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 457-64 (1959). In Roumanian.

A photographic arrangement was used to study the molecular scattering of light at 90° to the direction of the incident beam in fluorescent solutions. Light scattering was studied in very dilute solutions (0.06×10^{-2} to 0.4×10^{-2} g/cm^3) of quinine sulphate by determining the Rayleigh constant, the variation of refractive index with concentration and the depolarization factor of the scattered light. For the cases studied the results have shown the existence of a correlation between the degree of association of the solute in solution and the amount of fluorescence of the solution.

H.G.Jerrard

5283 ELECTRICAL RESISTIVITY OF LIQUID SODIUM, LIQUID LITHIUM, AND DILUTE LIQUID SODIUM SOLUTIONS.
J.F.Freedman and W.D.Robertson.

J. chem. Phys (USA), Vol. 34, No. 3, 769-80 (March, 1961).

The three factors of atomic size, ion core potential, and charge, which contribute to the increment in electrical resistivity produced by solutes in metallic solutions, were separated and experimentally evaluated in liquid sodium. The results may be expressed in a semiempirical relationship defining the increment in resistivity of a monovalent solution, $\Delta\rho = 0.063\ |\Delta \text{ Atomic Number}| + 0.53(\Delta V/V)^2$ μohm cm/at.%, where $\Delta V/V$ is the fractional difference in atomic volume of solute and solvent and the first term involves the absolute value of the difference in atomic number of sodium and the solutes lithium, potassium, caesium, rubidium, silver, and gold.

5284 CORRELATION BETWEEN ELECTRICAL RESISTIVITY AND INTERACTIONS BETWEEN THE COMPONENTS OF LIQUID METALLIC SYSTEMS. TERNARY SYSTEM Zn-Cd-Sb.
L.Oleari and M.Fiorani.

Ricerca sci. (Italy), Vol. 29, No. 12, 2589-97 (Dec., 1959). In Italian.

The electrical resistivity was measured as a function of composition and temperature, in order to obtain further information on short-range order in the ternary system Zn-Cd-Sb. Results correlate well with thermodynamical data. L.Pincherle

5285 PROTON RELAXATION TIMES IN PARAMAGNETIC SOLUTIONS. EFFECTS OF ELECTRON SPIN RELAXATION.
N.Bloembergen and L.O.Morgan.

J. chem. Phys. (USA), Vol. 34, No. 3, 842-50 (March, 1961).

The proton relaxation time in solutions of paramagnetic ions depends, among other factors, on the relaxation time of the electron spins, τ_S. It is shown that the latter, for ions of the iron group, is determined mostly by the distortion of the hydrated complex by collisions with other water molecules. The theory provides a quantitative explanation for the decrease in T_2 in Mn^{++} (and other) solutions in very high magnetic fields. The experimentally observed field and temperature dependence of the proton relaxation times, T_1 and T_2, for ions of the iron group is compared with theory and the features which depend on τ_S are stressed.

5286 ELECTRON SPIN RELAXATION IN METAL—AMMONIA SOLUTIONS.
V.L.Pollak.

J. chem. Phys. (USA), Vol. 34, No. 3, 864-72 (March, 1961).

The pulsed magnetic resonance technique was employed to measure the electron spin relaxation times T_1 and T_2 in solutions of sodium and potassium in liquid ammonia. Measurements were carried out over a range of temperatures from −50° C to + 30° C, and for the concentration range of 10^{-4} to 10^{-2} mole metal per mole NH_3. It was found that T_1 and T_2 are equal at all measured concentrations and temperatures, these times ranging from 1 to 3 μsec. For dilute solutions, the data are shown to be quantitatively consistent with the assumption that the relaxation is owing to the contact hyperfine interaction of the electrons with the N^{14} nuclei of ammonia. This interaction is modulated by the relative motion of the electrons and the ammonia molecules, the spin relaxation time being proportional to the modulation rate, as is typical in cases of extreme motional narrowing. An electron tunnelling mechanism is proposed as a possible source of the modulation. That the electron—nitrogen hyperfine interaction is largely responsible for the spin relaxation in dilute solutions is verified by measurements on a sample prepared from isotopically substituted ammonia ($N^{15}H_3$). A qualitative explanation of the variation of the electron spin relaxation time with concentration is proposed.

5287 THE MEASUREMENT OF INDIRECT (J) COUPLING BETWEEN NUCLEI IN LIQUIDS IN MAGNETIC RESONANCE BY THE TRANSIENT METHOD.
J.G.Powles and A.Hartland.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 273-7 (Feb., 1961).

An improved method of determining the indirect nuclear spin coupling J in magnetic resonance by the transient method is described. The reduction of self-diffusion method is described. The reduction of self-diffusion attenuation by complex pulse trains permits the observation of J modulation for times up to about one second and measurement of J to $\pm 1\frac{1}{2}\%$ or better. Chemical shifts δ can also be determined. Expressions are given for the echo modulation in some special cases and also a general method for obtaining them when $J \ll \delta$. The modulation patterns in methyl alcohol, ethyl alcohol and 2-bromo-5-chloro-thiophene are given.

MECHANICS OF GASES

5288 SOME FLOW PATTERNS AROUND A CIRCULAR CYLINDER IN A HIGH SUBSONIC FLOW OBSERVED BY USING SCHLIEREN AND SHADOW METHODS. S.Kageyama.
Mem. Defense Acad. (Japan), Vol. 1, No. 5, 14-16 (March, 1960).

5289 A CONTRIBUTION TO THE THEORY OF AXIALLY SYMMETRIC FLOW OF GASES. V.P.Karlikov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 5, 1049-52 (Aug. 11, 1960).
In Russian.

For abstract, see Abstr. 19174 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 694-7 (Jan.-Feb., 1961)].

5290 DENSITY FIELD FOR RAREFIED FLOW THROUGH AN ORIFICE. W.M.Howard.
Phys. of Fluids (USA), Vol. 4, No. 4, 521-4 (April, 1961).

A theoretical investigation is made of the density field for rarefied flow through an orifice. Within the assumptions of Maxwellian velocity distribution of the gas and of diffuse reflection from the reservoir walls, exact expressions are found for the density at the centre line of the effusing stream for a circular orifice and for all regions of the field for square and rectangular orifices. The density field is found to be most affected by orifice geometry in the region. For narrow slits the effect is felt further from the orifice than for nearly square or circular geometries.

5291 UNIFORM RAPID DEFORMATION OF [THE PATTERN OF] TURBULENCE IN GASES. V.A.Frost.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 773-6 (Aug. 1, 1960).
In Russian.

For abstract, see Abstr. 19180 of 1960. [English translation in: Soviet Physics — Doklady (USA), Vol. 5, No. 4, 690-3 (Jan.-Feb., 1961)].

Shock Waves

5292 A METHOD OF CALCULATION OF [THE PROPAGATION OF] SHOCK WAVES. V.F.Kuropatenko.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 771-2 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 19278 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 687-9 (Jan.-Feb., 1961)].

5293 HUGONIOT CURVE DETERMINED BY SHOCK WAVE DETACHMENT FROM AN INFINITE WEDGE.
W.A.Allen and J.W.Rogers.
Phys. of Fluids (USA), Vol. 4, No. 4, 493-7 (April, 1961).

A method is presented for the determination of the Hugoniot curve of an arbitrary inviscid compressible fluid flowing at supersonic speed past an infinite wedge. A shock wave is attached to the apex of the wedge provided the wedge angle is less than a certain critical value. The shock wave detaches from the wedge if the wed angle becomes greater than this critical value. If the Hugoniot cur of the fluid is known, the critical wedge angle can be calculated for a given initial fluid flow velocity. The critical angle also can be determined by an experimental method. This paper treats the theoretical problem of utilizing the discrepancy between theoretical pr dictions and experimental results to obtain an improved Hugoniot curve of the fluid. A perturbation method is applied to the case of solid copper for which both theoretical and experimental informati exists. The actual experimental Hugoniot curve for copper does no differ sufficiently from its theoretical value to yield a fair test of the method; therefore, synthetic experimental data are used to solv a typical numerical example. In the example treated, a 10% discre ancy between theory and experiment was reduced to about 1% by on application of perturbation theory.

MAGNETOHYDRODYNAMIC SHOCK WAVE IN A COLLISION-FREE PLASMA. See Abstr. 5453

SOME REMARKS OF ELECTRIC-DISCHARGE SHOCK TUBE DIAGNOSTICS. See Abstr. 5475

SHOCK WAVES AND SHOCK WAVE STRUCTURE IN MAGNETO-FLUID DYNAMICS. See Abstr. 5568

ON GAS-IONIZING MAGNETOHYDRODYNAMIC SHOCK WAVE See Abstr. 5570

GASEOUS STATE

5294 POLYNOMIAL REPRESENTATION OF EXPERIMENT DATA; APPLICATION TO VIRIAL COEFFICIENTS OF GASES. A.Michels, J.C.Abels, C.A.ten Seldam and W.de Graaff.
Physica (Netherlands), Vol. 26, No. 6, 381-91 (June, 1960).

The reliability of the polynomial representation of experimentally determined functions is investigated with emphasis on th application to compressibility isotherms of gases. Methods are described to obtain the series coefficients together with their uncertainties as a consequence of the inaccuracy of the experimen data. Results are given for the 49.712°C compressibility isother of CO_2

5295 CONTINUUM EQUATIONS IN THE DYNAMICS OF RAREFIED GASES. M.Krook.
J. fluid Mech. (GB), Vol. 6, Pt 4, 523-41 (1959).

A procedure is given for translating boundary-value problems gas dynamics from microscopic form into approximately equivalen continuum form. The continuum formulations involve state-variab that are either half-space moments, or complete moments of the molecular distribution functions. Moment equations derived from the kinetic equations are reduced to a determinate set by representing the distribution functions as sums of "modified Maxwellian functions based on various characteristic temperatures and velocities". The particular choice of such a representation depends on the Knudsen number and on the nature of the microscopic boundary conditions.

SOME NOTES ON THEORIES OF HELIUM. See Abstr. 5385

5296 ON THE VARIATION OF THE REFRACTIVE INDEX OF AIR WITH PRESSURE.
I.Agîrbiceanu, N.Comaniciu and V.Tatu.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 307-15 (1959).
In Roumanian.

Presents the results of the measurement of the refractive index of air for pressures lying between a few mm Hg and atmospheric pressure. A Fabry-Perot etalon in a barometric chamber is used whereupon the appearance of the interference pattern changes as the air pressure in the chamber is varied. A formula is deduced for the dependence of the radii of the interference rings on pressure from which is obtained an express for the refractive index as a function of pressure. A theoretical interpretation of the Barrel—Sears formula is given. The experimental values of the refractive indices are in agreement with the theoretical values up to the sixth decimal place. Also for the range of pressures studied the Lorentz—Lorenz formula is verified.
H.G.Jerra

5297 PARAMAGNETIC EFFECTS DUE TO THE VISCOUS FLOW OF MIXTURES OF GAS AND OXYGEN, IN A AGNETIC FIELD, AND THEIR USE IN THE ANALYSIS OF GASES. Ursu.
ud. Cercetari Fiz. (Roumania), Vol. 8, No. 4, 415-20 (1957). Roumanian.

The paramagnetic effects in the viscous flow of mixtures of gas d oxygen, in a magnetic field, and their use in the analysis of ises represents one part of the results of investigations regarding e magnetic variation of the viscosity of pure oxygen, as well as of ixtures of gas and oxygen. The paper deals with this effect in the ixtures oxygen—methane and oxygen—hydrogen, by means of ylindrical capillaries and porous materials. The experimental ethod used is merely an extension of that used by the author in arlier works and which is based on the reading of deviations of a palette" micromanometer. The results obtained from the experients on mixtures of gas and oxygen in the proportions of 40% and 0% oxygen show the way in which the viscosity depends on the magetic field and on the oxygen concentration, as well as the possibility applying the phenomenon to the analysis of gas containing oxygen, ith a precision of 0.4% oxygen. S.Weintroub

VACUUM PHYSICS

5298 STANDARD UNIT OF PRESSURE IN VACUUM PHYSICS. C.Volet; P.H.Bigg.
ature (GB), Vol. 188, 1017 (Dec. 17, 1960).

Referring to the previous communication by Florescu (Abstr. 222 of 1960) it is pointed out that the new unit advocated by him none other than the millibar. The extended use of the absolute it of pressure is supported by Bigg who gives a warning of the kely confusion resulting from Florescu's proposal to change the andard value of gravity. W.Steckelmacher

5299 MEASUREMENT OF PRESSURE IN VACUUM SYSTEMS. W.W.Forrest.
ature (GB), Vol. 189, 476 (Feb. 11, 1961).

Since the pressure in practical vacuum systems varies over any orders of magnitude, the author proposes an inverted logrithmic scale on which zero would correspond approximately to tmospheric pressure (10^6 dynes/cm^2), and all lower pressures ould be positive, the highest vacua being denoted by the highest umbers. L.M.Roberts

5300 ASPECTS OF VACUUM PHYSICS IN THE LIGHT OF RECENT DEVELOPMENTS. R.Jaeckel.
chweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 2-4 (Feb., 1961). In German.

Recent trends in ultra-high vacuum techniques are reviewed. W.Steckelmacher

5301 INTRODUCTION TO PROBLEMS ARISING IN THE PRODUCTION OF ULTRA-HIGH VACUA. E.B.Bas.
chweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 5-61 (Feb., 1961). In German.

A discussion of sources of gas in a low pressure vacuum ystem is followed by a review of number of possible ultra-high acuum pumping systems: the techniques involved in vapour pumps sing either mercury or oil together with refrigerated or sorption pe vapour traps, getter-ion pump systems, cryopumping or ystems using molecular pumps are considered. W.Steckelmacher

5302 INTEGRATION OF CURRENT THROUGH GETTER-ION PUMPS. J.R.Fendley, Jr.
ev. sci. Instrum. (USA), Vol. 31, No. 12, 1350 (Dec., 1960).

Integration of the discharge current in a getter-ion pump was sed as a measure of the quantity of gas gettered by the pump. A imple circuit is described in which the charge collected by a apacitor was used to trigger an impulse counter the dials of which ave a direct reading of integrated current. W.Steckelmacher

5303 THE KINETICS OF PUMPING OF VACUUM SYSTEMS IN THE QUASI-STATIONARY REGIME. V.A.Malȳshev.
h. tekh. Fiz. (USSR), Vol. 31, No. 2, 200-3 (Feb., 1961). In Russian.

According to simple theory, the velocity of pumping is indepenent of pressure. In practice this is not so, and a revised callation of pressure distribution in a pumping system, taking into ccount reverse flow through the pump, is carried out. The calculations are of practical use in determining the standard parameters characterising the behaviour of pumping system. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5304 THE MEASUREMENT OF ULTRAHIGH VACUUM. I. REVIEW. L.Patȳ.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 3-10 (Nov.-Dec.). In Russian.

Various modifications of the hot-cathode ionization manometer, constructions of the compression manometer for measuring pressures to 10^{-8} mm Hg, and the gas-discharge manometer with magnetic field and a measurement range to 10^{-14} mm Hg are examined, as well as devices in which adsorption phenomena on thermionic and cold emission cathodes are used for measuring pressures. 35 references. [English translation in: Instrum. exper. Tech. (USA), No. 6, 863-9 (Nov.-Dec., 1959; publ. Sept., 1960)].

5305 ANOMETERS FOR THE MEASUREMENT OF ULTRA-HIGH VACUUM. II. A.M.Grigor'ev.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 10-13 (Nov.-Dec.). In Russian.

Ionization and magnetic electric-discharge manometers are considered. [English translation in: Instrum. exper. Tech. (USA), No. 6, 870-2 (Nov.-Dec., 1959; publ. Sept., 1960)].

5306 VACUUM GAUGES. K.G.Müller.
Schweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 70-8 (Feb., 1961). In German.

A review of vacuum gauges dealing essentially with liquid level and mechanical manometers, thermal conductivity gauges and ionization gauges. Gauges for leak testing and pressure switching are briefly considered. W.Steckelmacher

5307 DESCRIPTION OF A GAUGE FOR ULTRA-HIGH VACUA AND REMARKS ABOUT ULTRA-HIGH VACUA TECHNIQUES FOR ALL-METAL MOUNTINGS. K.G.Muller.
Vide (France), Vol. 14, 250-9 (July-Aug., 1959). In French and English.

Describes the construction and characteristics of an Alpert-type gauge and discusses techniques for obtaining ultra-high vacua in all-metal systems using getter and ionization pumps. J.Dutton

5308 USE OF "AIR-BLEED" WHEN MEASURING PRESSURE IN VACUUM PROCESSES IN WHICH CONDENSABLE VAPOURS ARE PRESENT. H.Wycliffe.
J. sci. Instrum. (GB), Vol. 38, No. 4, 126-9 (April, 1961).

Condensation may occur in a vacuum gauge used for measuring the pressure in a vacuum system in which a liquid is being evaporated at elevated temperature and the pressure of the liberated vapour exceeds the saturation pressure of this vapour at the temperature of the vacuum gauge, which is usually at ambient temperature. A pressure-measuring method is described which prevents condensation or liquefaction occurring in the manometer or in the line connecting it to a vacuum system. The essence of this method is the reduction of the vapour pressure in the vacuum gauge, or in the pipeline leading to it, by a small stream of air, to a value at which condensation or liquefaction cannot occur. A short note is also added on the use of mercury manometers on "wet" vacuum systems.

5309 MEASURE OF SPEED OF OUTGASSING BY A METHOD DUE TO OATLEY. R.P.Henry.
Vide (France), Vol. 14, 226-40 (July-Aug., 1959). In French and English.

Methods of obtaining outgassing data of materials at low pressures are considered. The quantity of gas evolved from a sample contained in a chamber may be measured in terms of the pressure drop across a fixed thin aperture separating the chamber from the pump. This method is shown to have disadvantages compared with a method attributed to Oatley (see Abstr. 10883 of 1954 dealing with pumping speed measurements) in which pressure changes are measured while the aperture is varied in a known manner. Apparatus based on this method is described and some experimental results are given. W.Steckelmacher

5310 VACUUM SLUICE VALVE OF LARGE APERTURE. P.H.Lissberger.
J. sci. Instrum. (GB), Vol. 38, No. 4, 132 (April, 1961).

5311 **A VERSATILE METAL TO DIELECTRIC SEAL.**
P.C.Conder, H.Foster and H.A.H.Boot.
J. sci. Instrum. (GB), Vol. 38, No. 4, 134-6 (April, 1961).

A bakeable vacuum window seal suitable for use as an optical window or as a radio-frequency window for high power microwave applications is described. Fluid pressure, applied externally, compresses the window frame on to the edge of a dielectric disk. This pressure prevents the frame from expanding away during heating cycles irrespective of the differential thermal expansion between metal and dielectric. Silica and ceramic disks have been successfully sealed to stainless steel or copper frames and baked at 450°C.

5312 **LOW TEMPERATURE STATIC SEALS USING ELASTOMERS AND PLASTICS.**
D.H.Weitzel, R.F.Robbins, G.R.Bopp and W.R.Bjorklund.
Rev. sci. Instrum. (USA), Vol. 31, No. 12, 1350-1 (Dec., 1960).

The use of plastics (thin sheets of Mylar and nylon) and elastomers ($\frac{1}{8}$ in. diameter O-rings of rubbers and Viton A) for low temperature seals is described. Successful sealing was achieved with a seal designed to give high localized compression and small final thickness of the seal materials. W.Steckelmacher

5313 **HIGH-EFFICIENCY, LONG-LIVED VACUUM COLD TRAP.** J.W.Butler.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 211-16 (Aug., 1960).

The construction and performance of a vacuum cold trap for pump oil, "O"-ring, and other vapours are described. The trap has a capacity of 16 litres of liquid nitrogen, and lasts 5 days on one filling when clean. After a period of about 6 months to 1 year of continuous use, the lifetime drops to about 3 days. The trap has high pumping speed, and very high trapping efficiency, requiring a minimum of 3 successive cold-surface collisions for a molecule migrating through the trap. The principles of design include the use of very thin re-entrant tubes for mechanical support of the cold reservoir (thus minimizing conduction heat transfer), an inner tube for pumping and trapping, shields for reducing radiation heat transfer, and gold-plating for opposing surfaces having different temperatures. Mercury and oil diffusion pump systems are compared.

5314 **LIQUID NITROGEN FEEDING OF A MASS SPECTROGRAPH TRAP.** G.Seris and P.Vernotte.
Vide (France), Vol. 15, 109-11 (March-April, 1960). In French and English.

As the consumption of coolant is high in the case of constant level feeding, an automatic device was developed for filling up the cooling trap of a mass spectrograph from a storage vessel, each time the level of coolant in the trap had sunk to half its height. With a 50 litre storage vessel the liquid nitrogen supply to the trap could be maintained for 65 hours. R.Schnurmann

5315 **DEPOSITION OF FILMS BY EVAPORATION IN A VACUUM.** D.Hacman.
Schweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 62-6 (Feb., 1961). In German.

A historical review is followed by a short discussion of evaporation problems arising with a number of typical materials. W.Steckelmacher

5316 **THE IMPORTANCE OF VACUUM TECHNIQUES IN THE PRODUCTION OF STABLE BLOOD PREPARATIONS.**
R.Heiz.
Schweiz. Arch. angew. Wiss. Tech. (Switzerland), Vol. 27, No. 2, 67-9 (Feb., 1961). In German.

VIBRATIONS . ELASTIC WAVES

(See also Shock Waves)

5317 **TRANSFER-MATRIX FUNDAMENTALS.**
F.Leckie and E.Pestel.
Internat. J. mech. Sci. (GB), Vol. 2, No. 3, 137-67 (Nov., 1960).

Several authors have developed the method of transfer matric for the vibration and stability analysis of complicated elastic systems. This paper is an attempt to generalize and unify the method, so that many further problems may fall within its scope. The discussion is limited to the natural vibration of elastic system but once this has been established it is possible to extend the meth to cover forced vibrations and statics.

5318 **THE EFFECT OF SMALL CHANGES IN MASS AND STIFFNESS ON THE NATURAL FREQUENCIES AND MODES OF VIBRATING SYSTEMS.** R.P.N.Jones.
Internat. J. mech. Sci. (GB), Vol. 1, No. 4, 350-5 (July, 1960).

Exact equations are obtained for the changes in the natural frequencies and modes of an n-degree-of-freedom system, as a result of changes in the masses and elastic constants. These equations are in a form suitable for solution by successive approximation when the changes in the modes are small. A numerical example on a 5-mass flexural system is given.

5319 **SMALL VIBRATIONS OF THIN INCOMPLETE CIRCULAR RINGS.** R.R.Archer.
Internat. J. mech. Sci. (GB), Vol. 1, No. 1, 45-56 (Jan., 1960).

The in-plane inextensional vibrations of an incomplete circula ring of small cross section are studied by means of the classical equations of motion. Natural frequencies and modes are found for rings with clamped ends and subtended angles between 180° and 36 A solution is given for the problem of an incomplete ring clamped at one end and given a precribed, time-dependent displacement at the other end. [Comments on this paper appear in ibid., Vol. 1, No. 4, 397 (July, 1960), and Vol. 2, No. 1-2, 132 (Oct., 1960)].

5320 **FRICTIONAL OSCILLATIONS.**
R.T.Spurr.
Nature (GB), Vol. 189, 50-1 (Jan. 7, 1961).

A frictional contact between two solids can be made to perfor relaxation oscillations when one of the solids is moved forward a a slow uniform rate and the other solid is elastically restrained. A model experiment is now described in which the free end of a rigid strut rests on a moving surface and makes an angle θ with this surface. The other end of the strut is pivoted to another stru whose pivot is stiffer than the first. For this model "spragging" occurs if $\mu = \cot\theta$, where μ is the coefficient of friction. When sufficient elastic energy has been stored for the structure of stru and pivots to have become practically rigid, the angle θ is reduce to a smaller value θ', the frictional force falls and slipping occur R.Schnurma

5321 **SEPARATION OF THE VECTOR WAVE EQUATION OF ELASTICITY FOR CERTAIN TYPES OF INHOMOGENEOUS, ISOTROPIC MEDIA.** J.F.Hook.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 302-13 (March, 1961).

The method of separation of both the dependent and independe variables of the vector wave equation of elasticity has heretofore been applied almost exclusively to problems of wave propagation i homogeneous media. In this paper, a generalization of this metho is developed. The mechanical properties of the media considered here depend on one Cartesian coordinate, and Poisson's ratio is taken to be constant. Formulations are given for axially symmetr waves in three dimensions and for waves in two dimensions. Thre linearly independent vector solutions of the wave equation are expressed in terms of three scalar potential functions. One of these functions represents generalized SH waves and satisfies an indepe ent second-order wave equation in all the problems considered he Certain functional forms for the mechanical properties are found which the remaining two potential functions also satisfy independe second-order wave equations; these potentials may be identified w generalized P and SV waves, respectively. The SH waves are s noidal, but in general the P and SV waves are not purely irrotati and solenoidal, respectively, for the problems treated.

5322 **FEATURES OF THE ELASTIC WAVE SURFACE FOR ZINC CRYSTAL.** M.J.P.Musgrave and M.F.Markham
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 335-6 (Feb., 1961).

In recent years the elastic wave surfaces for certain crystals re calculated from observed values of physical constants. The rfaces show geometrical features which have interesting physical terpretation. Experiments designed to verify the existence of one the cuspidal edges on the wave surface for zinc are described.

ACOUSTICS

5323 MAGNETOSTRICTION FERRITES AS ELECTRO-ACOUSTIC TRANSDUCER MATERIALS. I.P.Golyamina.

kust. Zh. (USSR), Vol. 6, No. 3, 311-20 (1960). In Russian.

Describes measurements of mechanical properties (density, oung's modulus, etc.), magnetostriction and magnetic properties four ferrites intended as materials for electroacoustic trans-ucers. The four ferrites were: NiO.Fe$_2$O$_3$, NiO$_{0.5}$ZnO$_{0.5}$.Fe$_2$O$_3$, iO$_{0.99}$CoO$_{0.01}$.Fe$_2$O$_3$, and NiO$_{0.98}$CoO$_{0.02}$.Fe$_2$O$_3$. It was found that agnetostriction parameters of these four ferrites were comparable ith the parameters of the usual transducer materials, such as ickel, Permendur and Alfer. The dependence of the ferrite roperties on a constant magnetic field and on temperature was tudied. [English translation in: Soviet Physics—Acoustics (USA), ol. 6, No. 3, 311-20 (Jan.-March, 1961)]. A.Tybulewicz

5324 DISTORTION OF THE FINITE-AMPLITUDE [ACOUSTIC] WAVEFORM ON PROPAGATION IN A RELAXING EDIUM. E.V.Romanenko.

kust. Zh. (USSR), Vol. 6, No. 3, 374-80 (1960). In Russian.

Experimental study of waveform distortion at 1.08-3.4 Mc/s in a olution of MnSO$_4$ of 0-1.0 mole/litre concentration. The pressure amp-tude at the radiator surface was ~ 10 atm. The spectral composition the distorted wave and phase relationships between harmonics aried with distance from the radiator. The phase shift between the rst and second harmonics was practically independent of the wave mplitude, provided it was finite, and it was half that when two inde-endent waves were propagated with small amplitudes and frequencies qual to the first and second harmonics of the distorted wave. English translation in: Soviet Physics—Acoustics (USA), Vol. 6, o. 3, 375-81 (Jan.-March, 1961)]. A.Tybulewicz

5325 SYNTHESIS OF STEPPED ACOUSTIC TRANSMISSION SYSTEMS. J.E.Holte and R.F.Lambert.

. Acoust. Soc. Amer., Vol. 33, No. 3, 289-301 (March, 1961).

Procedures are described whereby acoustical systems support-g one-dimensional harmonic waves may be synthesized for a pre-cribed frequency dependence of the input reflection coefficient. An mportant design latitude is gained by allowing the nominal charac-eristic impedance of the structure to vary in a stepwise manner ith the independent space variable. An initial simplified model is resented which assumes only propagating plane waves and neglects ultiple reflections between discontinuities. These results are orrected to include the effects of multiple reflections by techniques rom signal flow graph theory. Effects of local higher-order modes xisting at the discontinuities are represented as lumped shunt sus-eptive elements. Data obtained from measurements on an acoustic atching section design operating between a 5.76 : 1 impedance mis-atch over a 50% bandwidth centred about 1333 c/s confirm the heoretical predictions. Further data, obtained from standing-wave easurements at the input to coupled resonator sections, indicate e importance of higher-order nonpropagating modes when the dis-ontinuities are large. It is found that effects of these modes upon e input reflection coefficient are readily obtained from Smith chart alculations. The synthesis procedures constitute a simple, rapid eans for initial design of a stepped structure to yield a prescribed requency dependence of input reflection coefficient by essentially raphical techniques. The most important unsolved problems are e direct inclusion of multiple reflections and susceptive discontinu-y effects in the synthesis procedure and the establishment of eneral physical realization criteria. Finally, it remains to relate e response of stepped systems to a more general smoothly varying ystem.

5326 INTEGRAL SOLUTION OF THE SHALLOW WATER SOUND FIELD. C.B.Leslie and N.R.Sorensen.

. Acoust. Soc. Amer., Vol. 33, No. 3, 323-9 (March, 1961).

A method is developed for the numerical evaluation of the tegral solution to the wave equation for a point source in shallow ater overlying a "hard" liquid type bottom; i.e., $c_2 > c_1$. This ethod is especially useful for intermediate horizontal ranges where satisfactory approximations to the sound field have not been found. In general the integral cannot be evaluated directly because there are singularities in the integrand. Instead it has been transformed into the complex plane in such a way that the resulting integrals and residues can be evaluated on a high speed digital computer. A limited number of calculations were made to illustrate the use of the numerical method.

5327 THE CALCULATION OF THE VERTICAL SOUND VELOCITY PROPAGATION PROFILES IN MARINE MEDIA.

L.M.Brekhovskikh, V.A.Evtushenko, S.S.Makarov and V.F.Pisarenko.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 581-3 (Nov. 21, 1960). In Russian.

The limitations of the existing method of calculating the variation with depth of sound velocity in the sea are analysed. A "method of characteristic points" is proposed, based on the division of the depth into layers and assuming a constant velocity gradient throughout each layer. The method is applied to finding the sound velocity profiles in the warm North Atlantic and the cold Labrador currents. R.F.S.Hearmon

5328 LONG-RANGE MEASUREMENT OF SOUND SPEED IN SEA WATER. G.R.Garrison, P.C Kirkland and S.R.Murphy.

J. Acoust. Soc. Amer., Vol. 33, No. 3, 360-1 (March, 1961).

Measurements of the speed of sound in sea water by transmitting sound pulses a distance of 1000 yards are in agreement with the +0.2% correction to the Kuwahara tables recommended by Del Grosso and Wilson.

5329 SPEED OF SOUND IN HEAVY WATER AS A FUNCTION OF TEMPERATURE AND PRESSURE. W.D.Wilson.

J. Acoust. Soc. Amer., Vol. 33, No. 3, 314-16 (March, 1961).

The speed of sound has been measured in heavy water, D_2O, by a pulse technique. An equation is presented to express the results of these measurements in analytic form and is used to compute tables of sound speed in D_2O. A comparison of the sound speeds in D_2O at atmospheric pressure obtained by an optical method, an interferometer method, and the present pulse method is made. The results from the pulse method and the optical method agree within the experimental error; however, the interferometer method gave higher sound speeds than the other two.

5330 EFFECT OF A REFLECTING PLANE ON AN ARBITRARILY ORIENTED MULTIPOLE. D.A.Bies.

J. Acoust. Soc. Amer., Vol. 33, No. 3, 286-8 (March, 1961).

Expressions for the power radiated by either a dipole or a quadrupole reflected in an infinite rigid plane are presented. These expressions are perfectly general in that they admit any orientation of the multipole and any kind of a quadrupole. The results include the special cases considered previously by Ingard and Lamb (see Abstr. 2202 of 1958). The large variations in radiated power observed for a single multipole tend to diminish when averages over a distribution of such multipoles are considered.

5331 THEORETICAL DEVELOPMENT OF VOLUME REVERBERATION AS A FIRST-ORDER SCATTERING PHENOMENON. H.R.Carleton.

J. Acoust. Soc. Amer., Vol. 33, No. 3, 317-23 (March, 1961).

A model for acoustic scattering of an arbitrary pressure wave is developed from the fundamental wave equation. A statistical distribution of scatterers in the medium is assumed and is described by a spatial correlation function. It is shown that the predominant features of volume reverberation can be derived from the model. Furthermore, under certain simplifying conditions, it is shown that the reverberation signal can be represented as a random noise passed through a narrow band filter whose properties are determined by the mode of transmission. The determination of the dependence of reverberation level on operating frequency, and the possibility of optimizing an acoustic system by the choice of transmission is suggested.

5332 EXACT SOLUTION OF WAVE SCATTERING BY IRREGULAR SURFACES. H.W.Marsh.

J. Acoust. Soc. Amer., Vol. 33, No. 3, 330-4 (March, 1961).

The problem which Lord Rayleigh considered (reflection from a corrugated surface) and which several have treated approximately in recent years, is developed in a general form. An exact solution is obtained by extensive use of Wiener's generalized harmonic analysis. This solution is readily extended to include electromagnetic waves, general elastic waves, and nonplanar, nonharmonic sources. Numerical evaluation of the formulae is considered by means of an operational representation, from which various types of successive approximations can be constructed. Applications can be of special interest in scatter communications and in underwater sound transmission and reverberation. Experimental evidence from the latter area indicates that a rather detailed theory is neccessary for an adequate account of the situation.

5333 SCATTERING OF UNDERWATER SOUND BY THE SEA SURFACE. H.W.Marsh, M.Schulkin and S.G.Kneale.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 334-40 (March, 1961).

A theory is presented of the scattering of underwater sound by the sea surface. The Neumann—Pierson oceanographic model of the sea is used. These developments are applied to propagation in an isothermal surface-bounded channel. A theoretical curve is presented of surface loss versus the r.m.s. wave height and frequency product at the lower end of the curve.

Instruments and Measurements

5334 A VERSATILE METHOD FOR SHORT-TERM SPECTRUM ANALYSIS IN "REAL-TIME". J.S.Gill.
Nature (GB), Vol. 189, 117-19 (Jan. 14, 1961).

Describes the production of an acoustic (speech, music etc.) spectrogram, in the frequency range 50 c/s to 3.3 kc/s, by continuously storing the immediate past 45 msec of input waveform and repeatedly presenting it to a single analysing filter of fixed bandwidth, with a superimposed frequency shift of the signal between each repetition. The input is sampled at 150.5 μsec intervals, encoded into 6 binary digits and stored in circulating delay lines. The outputs from these are decoded into analogue form and passed to the analysing filter through a frequency changer controlled by a multivibrator to give 150 sequentially stepped frequency shifts. The output from the filter, suitably demodulated, intensity modulates a c.r.o. whose Y plates, fed by a staircase waveform, give a displacement corresponding with the frequency shift, i.e. a vertical frequency axis is obtained. A continuously moving film provides the real-time axis. A block diagram and typical spectrogram for several analysis bandwidths, are given. T.H.D.Attewell

OPTICS . PHOTOMETRY

5335 EFFECT OF LIGHT INTENSITY DISTRIBUTION ON THE LIMITING DISTANCE IN PHOTOMETRY.
H.J.Hentschel.
Lichttechnik (Germany), Vol. 12, No. 12, 673-4 (Dec., 1960).
In German.

Assuming a distribution represented by $I_\theta = I_0 \cos^n\theta$, where n may have any value from −2 to 4, the author calculates the relation between distance and the error involved in using the inverse square law. J.W.T.Walsh

DESCRIPTION OF A MIRROR SYSTEM WITH 120° OF FIELD, FOR THE PHOTOGRAPHIC PHOTOMETRY OF EXTENDED CELESTIAL SOURCES. See Abstr. 5122

GEOMETRICAL AND INSTRUMENTAL OPTICS SPECTROSCOPY

(Optical spectra and their analysis are included under the appropriate heading, e.g. Atoms, Molecules, Solid-State Physics, etc.)

5336 A POINT SOURCE OF LIGHT IN AN ABSORBING MEDIUM BETWEEN PARALLEL PLANE SURFACES.
I.N.Minin.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 74-6 (July 1, 1960).
In Russian.

For abstract, see Abstr. 14793 of 1960. [English translation in: Soviet Physics — Doklady (USA), Vol. 5, No. 4, 754-6 (Jan.-Feb., 1961)].

5337 MUTUAL REFLECTIONS BETWEEN DIFFUSING SURFACES. J.Dourgnon.
Rev. Opt. (France), Vol. 38, No. 8, 365-94 (Aug., 1959). In French

The fundamental relations between exchange functions, form factors and total fluxes are expressed in matrix form. Some methods of solution, including the use of analogue computors, are outlined. This is mainly a review paper and there are 55 referenc W.T.Welfo

5338 IMPROVEMENT OF ABERRANT IMAGES BY MEANS OF SPATIAL FREQUENCY FILTERING. II. IMPROVEMENT OF AN IMAGE WHOSE [SPATIAL] SPECTRUM INCLUDES A NEGATIVE VALUE. J.Tsujiuchi.
Optica Acta (Internat.), Vol. 7, No. 4, 385-98 (Oct., 1960).
In French.

For Pt I, see Abstr. 19372 of 1960. The image formed by an objective whose response function takes zero and negative values modified by filtering of spatial frequencies, using a combination of phase and amplitude filters. It is found that a parasitic image appears in the modified image, produced by the zero values of the response function of the objective.

5339 THE SEPARATION OF SYMMETRICAL AND ASYMMETRICAL WAVE-FRONT ABERRATIONS IN THE TWYMAN INTERFEROMETER. P.Hariharan and D.Sen.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 328-34 (Feb., 1961).

By reflecting the two wave-fronts emerging from a Twyman interferometer back through the interferometer once again, it iss possible to obtain two separate interferograms showing, respectiv the symmetrical and asymmetrical parts of the wave aberration of an optical system (a lens). These can then be analysed to obtain th various aberration coefficients of the system in a very simple manner.

5340 OPTICAL IMAGE ASSESSMENT.
N.S.Kapany.
Nature (GB), Vol. 188, 1083-6 (Dec. 24, 1960).

Describes a method for generating the image of an extended object by projecting the point spread function through a transparen of the object and the measurement of frequency response by passi the line spread function through a sine curve transparency.
W.T.Welfo

5341 HIGH-PRECISION POINTING.
A.Maréchal.
J. Opt. Soc. Amer., Vol. 51, No. 4, 396-8 (April, 1961).

Two methods permitting high-precision pointing (image locati have recently been developed by members of the staff of the Instit d'Optique. The method of Simon for high precision in longitudinal positioning is based on the use of two identical grids, longitudinall separated, one forward and one back of the object point. The posi tion is determined by observing the equality of contrast of the out of-focus images of the grids. The method of Arnulf and Duppuy f lateral pointing is based on the formation of a system of interfere fringes by light from a double slit illuminated by light from a sing slit. By placing the entrance pupil of a telescope on a dark fringe the image of the slits, though very dim, reveals and amplifies any irregularities in the edges of the slits even though the irregularit are very small. If the two slits are separated only by a fine line, the lateral position of this line can be located with high precision.

5342 THE EFFECT OF THE ANGLE OF A PRISM ON ITS DISPERSION AND DISPERSIVE POWER.
.V.Kameswara Rao and V.Ramakrishna Rao.
. sci. industr. Res. (India), Vol. 19B, No. 11, 444-5 (Nov., 1960).

Expressions which include terms containing powers of the angle f prism are derived for the dispersion and dispersive power of a rism made of typical dense flint glass. Using the expansions of igonometric functions, the dispersion and dispersive power are hown to depend on the powers of the angle of the prism. The omputed values of these two parameters for various angles of e prism, obtained by using such series expansion formulae agree ell with those derived from the trigonometric formulae, which do ot involve any approximations. The use of the expansion formulae s suggested for calculations in the design of achromatic prisms ecause of their relative simplicity.

LIGHT GATHERING IN LARGE SCINTILLATORS. See bstr. 4746

5343 CALCULATION OF WAVELENGTHS FROM REFLECTING ECHELON PATTERNS.
.A.Hands, W.A.Heslop and T.A.Littlefield.
ptica Acta (Internat.), Vol. 7, No. 4, 325-30 (Oct., 1960).

Wavelengths are calculated from measurements of reflecting chelon patterns by a simplified procedure which can be carried ut conveniently, using a digital computer. By measuring to the osition of the centre of the envelope, rather than to an arbitrary nirror image as hitherto, it is shown that envelope correction is utomatically applied and a very simple correction for non-linearity f dispersion may be made where necessary.

5344 AUTOMATIC RECORDING OF THE BLACKENING OF PHOTOGRAPHIC PLATES WITH THE ZEISS RAPID HOTOMETER. G.Schultz and F.Treucker.
xper. Tech. der Phys. (Germany), Vol. 8, No. 5, 229-31 (1960). n German.

The Zeiss instrument can be adapted for use with a commercial ecorder to give the density curves of spectrograph plates with a igh degree of reproducibility. The modifications necessary and etails of a suitable recorder commercially available are described. Iagnifications from 50:1 to 2:1 can be used. J.W.T.Walsh

5345 A LOGARITHMIC PHOTOMETER FOR THE 0.2-0.7 μ REGION. V.I.Dianov-Klokov.
'ribory i Tekh. Eksper. (USSR), 1959, No. 6, 91-4 (Nov.-Dec.). In tussian.

A description is given of a photometer attachment to a monohromator; it records the logarithm of the intensity ratio of two ight beams by means of a logarithmic-response diode that acts as he load of a photomultiplier. The ratio of the beams can extend up o 10^4 : 1. A potentiometer recorder traces out the spectrogram. English translation in: Instrum. exper. Tech. (USA), No. 6, 949-52 Nov.-Dec., 1959; publ. Sept., 1960)].

5346 INFRARED SPECTROSCOPY OF MELTS AND HYGROSCOPIC GLASSES.
.D.Mackenzie, R.S.McDonald and W.K.Murphy.
tev. sci. Instrum. (USA), Vol. 32, No. 2, 118-21 (Feb., 1961).

Two techniques have been developed for the measurement of he infrared absorption of glasses at room temperature and of heir melts up to 100°C. In a vertical film apparatus, dehydration nd the control of sample thickness may be carried out imultaneously. At high temperatures, the breakage of the film hrough flow is circumvented by a horizontal film arrangement. 3y the formation of suitable thin films in situ, rapid absorption of vater is prevented. These methods are thus particularly suitable or highly hygroscopic materials where the conventional KBr disk echnique is unsatisfactory. The advantages of the two techniques re demonstrated by measurements carried out on glassy and iquid B_2O_3 up to 1000°C.

5347 NEW METHOD FOR SEALING INFRARED WINDOW MATERIALS TO GLASS. D.E.Martz.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 214-15 (Feb., 1961).

An epoxy resin with a filler of lithium aluminium silicate is ised as window seal in a permanently sealed vacuum Dewar develo-ed for infrared transmission studies on certain materials immersed n liquid gases. G.I.W.Llewelyn

5348 REVISED CALIBRATION FOR HIGH PRESSURE OPTICAL BOMB. H.G.Drickamer.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 212-13 (Feb., 1961).

Previous calibrations (Abstr. 8798 of 1960) for a high pressure optical bomb used for spectral measurements have been found to be inaccurate above 140 kilobars pressure due to elastic and plastic deformation. Corrected calibrations are presented. G.I.W.Llewelyn

5349 COMPARATIVE EXPERIMENTS WITH DIFFERENT METHODS OF EQUIDENSITOMETRY. C.Hiller.
"Optics of all wavelengths" Meeting, Jena, 1958 (see Abstr. 224 of 1961) p. 332-48. In German.

An account is given of six photographic and four electronic methods of producing lines of equal density in a photographic image (isophots). Typical patterns are shown from astronomy, electron diffraction, etc. and the isophots obtained by photographic and electronic methods are compared. R.W.Fish

STABILITY OF ELECTRIC ARCS AS LIGHT SOURCES. See Abstr. 5436

ESTIMATION OF SMITH—PURCELL EFFECT AS THE LIGHT SOURCE IN THE INFRARED REGION. See Abstr. 5576

PHYSICAL OPTICS

(Luminescence is included under Solid-State Physics, Liquid State, or Gaseous State)

5350 THE STUDY, PRODUCTION AND CONTROL OF THIN FILMS GIVING A CHOSEN PATH DIFFERENCE BETWEEN PERPENDICULARLY POLARIZED COMPONENTS. P.Lostis.
Rev. Opt. (France), Vol. 38, No. 1, 1-28 (Jan., 1959). In French.

The path difference obtainable by oblique transmission through a single thin film is small ($<\lambda/20$) but by total internal reflection any desired phase change can be introduced with a single film of refractive index in the range of known materials. A method of controlling the film thickness by the change in frequency of a vibrating quartz plate on which the film is evaporated is described, the total deposited mass being measured. The phase difference was checked during evaporation by means of a Babinet compensator. W.T.Welford

5351 DOUBLE-PASSED FIZEAU INTERFEROMETER. II. FRINGE SYSTEMS FORMED BY THE REFLECTED BEAMS. P.Hariharan and D.Sen.
J. Opt. Soc. Amer., Vol. 51, No. 4, 400-4 (April, 1961).

For Pt I, see Abstr. 16890 of 1960. The theoretical intensity distribution in the fringes formed when the reflected beams from a Fizeau interferometer are reflected back through the instrument is obtained. It is shown that, under certain conditions, the intensity distribution in these fringes exhibits a periodic modulation as the separation of the plates is changed, so that they can also be used for very accurate measurements.

THE SEPARATION OF SYMMETRICAL AND ASYMMETRICAL WAVE-FRONT ABERRATIONS IN THE TWYMAN INTERFEROMETER. See Abstr. 5339

5352 PHASE DISPERSION IN INTERFEROMETRY. P.E.Ciddor.
Optica Acta (Internat.), Vol. 7, No. 4, 399-403 (Oct., 1960).

It is shown that the interference equation for interferometers exhibiting phase-change effects should take the form $M\lambda = 2d - \lambda v/\pi$, where v is $(\beta - \pi)$ and β is the phase-change at reflection for one reflecting surface. Several recent treatments of the phase-change on reflection are critically examined and it is shown that the phase-dispersion deduced from them is inconsistent with generally accepted experimental results for interferometers with silver films.

5353 INTERFEROMETRIC METHODS FOR THE PHOTOGRAPHIC PRODUCTION OF LARGE GRATINGS.
J.M.Burch and D.A.Palmer.
Optica Acta (Internat.), Vol. 8, No. 1, 73-80 (Jan., 1961).

The need for new types of coarse grating for moiré fringe applications has aroused fresh interest in the possibility of using interferometry to generate gratings photographically. It is shown that this is now practical, and that certain commercially available emulsions have adequate resolving power and freedom from distortion. A large two-beam interferometer was constructed which is capable of producing gratings with between 1000 and 5000 lines per inch with an aperture 18 in. in diameter. The design and adjustment of the instrument are described. Large gratings of 1150 lines per inch were produced, and their application to stellar spectroscopy is being investigated. It is hoped to make the fringe spacing continuously variable, and this will open up further spectroscopic possibilities on the lines suggested by Connes (1959).

5354 PRINCIPLE AND REALIZATION OF A NEW TYPE OF INTERFERENCE SPECTROMETER. P.Connes.

Rev. Opt. (France), Vol. 39, No. 9, 402-36 (Sept., 1960). In French.

Continuation of a previous analysis of grating interferometers (see Abstr. 5498 of 1959). Defects in spectroscopes are classified. Aberrations, crossed gratings, mechanical tolerances, etc. are discussed. Experimental arrangements for testing theoretical conclusions are described. The resolving power of the grating interferometer constructed was tested and the attenuation of the orders studied. S.Tolansky

5355 DIFFRACTION EXPERIMENTS IN MULTIPLE-BEAM INTERFEROMETRY. G.Simonsohn.

Optica Acta (Internat.), Vol. 8, No. 1, 33-47 (Jan., 1961). In German.

A groove 3 to 30 μ wide runs across an almost opaque silver layer on a flat glass substrate; above it — in a plane parallel position at distances of between 8 and 50 μ — there is a glass mirror covered by a partly transmitting evaporated layer. In the initial experiments the bottom of the groove was not covered by any deposit; in the second part a partly transmitting layer was evaporated on it. This object was examined in transmitted light using fringes of equal chromatic order. Evidence is found of radiation which leaves the object at finite angles θ with the direction of the incident wave (normal direction). The phenomena outside the groove can be ascribed to discrete "angular orders" according to the relation $n.\lambda = 2d.\cos\theta$. In the case of the groove being covered by a layer, interference within the groove shows secondary maxima and a principal maximum along the direction $\theta = 0$. The positions of the secondary maxima are determined by the width of the groove. It is briefly indicated how all the observed phenomena could be explained by means of a waveguide model.

5356 MULTIPLE-BEAM INTERFERENCE AS A WAVE-GUIDE PROBLEM. G.Simonsohn.

Optica Acta (Internat.), Vol. 8, No. 1, 49-60 (Jan., 1961). In German.

The preceding paper described diffraction experiments on a simple object of multiple-beam interferometry: a narrow groove in a flat mirror divides the interference space between two mirrors into three plane-parallel regions, a groove region and two adjoining plateau regions. The results of these experiments allowed extension of the elementary description of multiple-beam interference. The plateau regions are associated with a series of waveguide modes which are being excited by the incident radiation penetrating the groove region. In the groove region standing waveguide modes appear. Due to the continuity of the electromagnetic field, the waveguide modes of the plateau regions are coupled with resonances in the groove region. These considerations lead to a correct description of the experimental results. Moreover it can be assumed that in general waveguide phenomena play a part in diffraction in multiple-beam interferometry.

5357 MULTIPLE DIFFRACTION BY AN APERTURE IN A HARD SCREEN. S.N.Karp and J.B.Keller.

Optica Acta (Internat.), Vol. 8, No. 1, 61-72 (Jan., 1961).

Two methods previously applied to diffraction by an aperture in a soft screen (one on which the field vanishes) are adapted to the case of a hard screen (one on which the normal derivative of the field vanishes). These methods are the geometrical theory of diffraction and the self-consistent field methods. They are both applied to diffraction by an infinite slit and both yield the same results at distances greater than several wavelengths from the edges of the screen. The former is also applied to diffraction by a circular aperture. Expressions for the diffracted fields, the diffraction patterns and the transmission cross-sections are obtained for the problems of the slit and the circular aperture. Graphs of the transmission cross-sections are given for normal incidence.

5358 DIFFRACTION OF PARTIALLY COHERENT LIGHT BY A PLANE APERTURE.

G.B.Parrent, Jr and T.J.Skinner.

Optica Acta (Internat.), Vol. 8, No. 1, 93-102 (Jan., 1961).

Using the formulation of coherence theory as introduced by Wolf, the diffraction of partially coherent light is discussed. The mutual coherence function and the intensity distribution are computed for a plane slit illuminated by coherent, partially coherent and incoherent light. The results are plotted and discussed.

CALCULATION OF WAVELENGTHS FROM REFLECTING ECHELON PATTERNS. See Abstr. 5343

5359 THEORETICAL INVESTIGATIONS ON THE LIGHT SCATTERING OF COLLOIDAL SPHERES. IX. LATERAL SCATTERING AT 90° FROM INCIDENT NATURAL AND LINEARLY POLARIZED LIGHT.

W.J.Pangonis, W.Heller and N.A.Economou.

J. chem. Phys. (USA), Vol. 34, No. 3, 960-70 (March, 1961).

For Pt VIII, see Abstr. 5182 of 1960. The Mie quantities $i_{||}$, $i_{\perp}$ and their sum are calculated for nonabsorbing spheres for the parameters $\gamma = 90^{\circ}$, $m = 1.05\ (0.05)\ 1.30$ and $\alpha = 0.2\ (0.2)\ 25.6$. The experimentally important specific scattered intensity $(I_u/I_0 c)_0$ is derived from $(i_{||} + i_{\perp})/2$. The periodicities in the prominent (secondary) $i\ (\alpha)$ oscillations and in the less pronounced primary and tertiary oscillations are briefly discussed.

5360 THEORETICAL INVESTIGATIONS ON THE LIGHT SCATTERING OF COLLOIDAL SPHERES. X. "SCATTERING RATIO" AND DEPOLARIZATION OF LIGHT SCATTERED AT AN ANGLE OF OBSERVATION OF 90°.

W.Heller, W.J.Pangonis and N.A.Economou.

J. chem. Phys. (USA), Vol. 34, No. 3, 971-9 (March, 1961).

The scattering ratio σ for nonabsorbing spheres and for an angle of observation γ of 90° is calculated from data given in Pt IX (preceding abstract), for $m = 1.05\ (0.05)\ 1.30$ and $\alpha = 0.2\ (0.2)\ 25.6$. The scattering ratio represents the ratio of the total intensities scattered from a linearly polarized incident beam vibrating once parallel and, subsequently, perpendicular to the plane of observation. In the present instance of spheres, the results are identical with the depolarization in infinitely dilute systems. The experimentally attractive features of σ measurements are pointed out and the precautions to be observed for useful application of the theoretical data are enumerated. The periodicities in the $\sigma\ (\alpha)$ curves due to the primary, secondary, and tertiary undulations in the basic $i\ (\alpha)$ functions are briefly discussed with particular emphasis upon selecting conditions of optimum sensitivity of the method for particle size determinations, characterized by an error of not more than 1-3 A in particle diameter in monodisperse systems.

5361 MEASUREMENT OF DIFFUSION.

J.Krochmann.

Lichttechnik (Germany), Vol. 13, No. 1, 16-19 (Jan., 1961). In German.

The diffusing power of a translucent material has been variously defined, usually by a relation between the light transmitted directly and that diffused, the incident light being a beam normal to the surface of the material. The author discusses the relationships between the various definitions and goes on to examine the method of measurement of the diffused light, as described in the German standard, and to suggest certain improvements. He then describes other tests for such materials, such as an estimate of the "see-through" and of the haze factor, and shows how materials which have a similar rating on one basis may be rated very differently on another. J.W.T.Walsh

DIFFUSION OF RADIATION IN A MEDIUM WITH A SPECULARLY REFLECTING BOUNDARY. See Abstr. 5237

COLORIMETRY . PHOTOGRAPHY

5362 MEASUREMENT OF CAMERA SHUTTER SPEEDS WITH COUNTER-CHRONOGRAPH. S.Z.R.Hashmi.
J. sci. industr. Res. (India), Vol. 19B, No. 3, 114 (March, 1960).

A counter chronograph is modified for the measurement of shutter speeds. A photomultiplier tube produces a d.c. signal as the shutter opens to operate a gate circuit. As soon as the light is cut off, the gate closes. The number of pulses recorded on the counter indicate the open time of the shutter. R.W.Fish

FACTORS INFLUENCING PHOTOGRAPHIC SENSITIVITY TO NUCLEAR PARTICLES. See Abstr. 5619

HEAT . RADIATION

5363 RECENT ADVANCES OF DISTILLATION TECHNIQUES. I. B.Brigoli.
Energia nucleare (Italy), Vol. 7, No. 9, 590-6 (Sept., 1960). In Italian.

The paper deals with heat and mass transfer and vapour-liquid equilibria studies presented at the "International Symposium on Distillation" held in Brighton, England, from 4th to 6th of May 1960.

THERMAL EXCHANGE FOR NON-NEWTONIAN FLUIDS IN LAMINAR MOTION IN CIRCULAR TUBES. See Abstr. 5255-6

5364 SOME RESULTS ON HEAT-TRANSPORT BY CONVECTION IN PRESENCE OF IMPRESSED MAGNETIC FIELDS. Y.Nakagawa.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 916-18 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The effect of an impressed magnetic field on heat-transport by convection, which arises from instability, has been examined by using a layer of mercury bound between two constant temperature surfaces. It is found that (1) an impressed magnetic field reduces the amount of heat transported by convection, and (2) in the neighbourhood of the marginal state of stability, heat-transport can be characterized by a simple linear formula which has been predicted theoretically by the author.

5365 THEORIES OF THE RADIOMETRIC EFFECT. I. C.Tomozei.
Stud. Cerçetari stiint., Fiz. Stiint. tehn. (Roumania), Vol. 11, No. 1, 93-109 (1960). In Roumanian.

The first experimental and theoretical investigations of the radiometric effect (the force acting on a body which is irradiated while suspended in a fluid) are described. The theories concerning this effect, which were formulated by Einstein (1922), Hettner (1924), Einstein (1924) and Sterntal (1926), are separately outlined and evaluated. It is concluded that the radiometric effect is basically a superposition of a series of effects, and that each of the theories mentioned explains one or more of these effects, while none explains them all, simultaneously. Five applications of the radiometric effect are reviewed. L.Mordecai

COMBUSTION IN A TURBULENT BOUNDARY LAYER. See Abstr. 4369

5366 MERCURY SWITCH FOR ESTABLISHING THE TRUE ELECTRICAL ZERO IN PRECISE THERMOCOUPLE MEASUREMENTS. J.Middlehurst.
J. sci. Instrum. (GB), Vol. 38, No. 4, 165-6 (April, 1961).

5367 UTILIZATION OF AN INDIUM–GERMANIUM ALLOY DIODE AS A TEMPERATURE TRANSDUCER. R.E.Smolyanskii.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 83-5 (Nov.-Dec.). In Russian.

An instrument is described which utilizes commercially-produced crystal diodes and measures temperature in the range from 20° to 60° C with an accuracy of tenths of a degree. It is shown that a hermetically sealed In–Ge diode can be used as a temperature transducer. The forbidden band width of Ge is calculated from the relation between the diode reverse current and temperature. [English translation in: Instrum. exper. Tech. (USA), No. 6, 941-4 (Nov.-Dec., 1959; publ. Sept., 1960)].

5368 SIMPLE IMPROVED THERMOSTAT SYSTEM. D.Shanefield.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 211-12 (Feb., 1961).

A simple mechanical device is proposed to overcome the effects of large changes of line voltage. Results are not given, but by implication regulation of the order of 0.001°C is attainable. E.G.Knowles

5369 A HIGH-TEMPERATURE RESISTANCE FURNACE WITH A GRAPHITE HEATER.
V.V.Dobrovenskii and N.D.Zherebtsova.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 126-7 (Nov.-Dec.). In Russian.

A simple resistance furnace is described with a shaped graphite heater, which provides, either in vacuum or in a protective gas, high temperatures for relatively small currents. The method of manufacturing the heater and its suspension from the body of the furnace by means of high melting-point insulators is described. [English translation in: Instrum. exper. Tech. (USA), No. 6, 983-4 (Nov.-Dec., 1959; publ. Sept., 1960)].

5370 15TH CALORIMETRY CONFERENCE. D.W.Osborne.
Phys. Today (USA), Vol. 14, No. 2, 44-6 (Feb., 1961).

A report of the conference held on 7-10 Sept., 1960 at Gatlinburg, Tennessee. 106 calorimetrists from the U.S., Canada and Europe heard and discussed 31 technical papers on recent work on many phases of calorimetry and engaged in informal discussions of calorimetric problems. Among the topics discussed were calorimetry at temperatures as low as 0.1°K and as high as 2800°K, precision reaction and bomb calorimetry, solution calorimetry, applications of calorimetry to solid-state problems, applications to radiation dosimetry, improvements in temperature measuring devices, and data processing by digital computers.

5371 CALORIMETER FOR THE CONTINUOUS STUDY OF THE HEAT PRODUCTION OF MICROBIAL SYSTEMS.
W.W.Forrest.
J. sci. Instrum. (GB), Vol. 38, No. 4, 143-5 (April, 1961).

The calorimeter described is suitable for the continuous study of the heat production of microbial systems. The instrument is self-balancing, heat production in a reaction vessel being simulated by electrical heating of an identical balance vessel. A continuous record of the electrical heat supplied to the system is presented on a strip-chart. Provision is made for stirring, sampling and maintenance of a controlled atmosphere. The vessels may be sterilized and are inert towards the systems to be studied.

5372 LIQUID NITROGEN CRYOSTAT FOR ELECTRICAL MEASUREMENTS ON CRYSTAL SAMPLES IN MAGNETIC AND LIGHT FLUXES. C.M.Hurd.
J. sci. Instrum. (GB), Vol. 38, No. 4, 160-1 (April, 1961).

5373 A LEVEL CONTROLLER FOR LIQUID NITROGEN. D.Miller and H.C.Evans.
J. sci. Instrum. (GB), Vol. 38, No. 4, 162-3 (April, 1961).

CHANGE OF STATE

(Solid-state phase transformations are included primarily under Structure of Solids)

GEOMETRIC BASIS OF PHASE CHANGE. See Abstr. 5270

5374 VAPOR PRESSURE OF NEARLY CLASSICAL LIQUIDS. W.A.Steele.
J. chem. Phys. (USA), Vol. 34, No. 3, 802-3 (March, 1961).

The reduced vapour pressures of liquids which exhibit nearly classical behaviour are considered. It is shown that the intermolecular quantum effects upon the parameters of the reduced vapour pressure equations of such liquids are small compared to other variations in these parameters. However, these effects can be reasonably well estimated by considering the changes in vapour pressure upon isotopic substitution in suitable simple systems. Experimental data are analysed to give quantitative estimates of the quantum effect upon the reduced heat of vaporization, the temperature-independent term in the vapour pressure equation, and the configurational heat capacity of nearly classical liquids.

5375 GROWTH OF A VAPOR-FILLED CAVITY NEAR A HEATING SURFACE AND SOME RELATED QUESTIONS.

K.E.Forster.
Phys. of Fluids (USA), Vol. 4, No. 4, 448-55 (April, 1961).

The growth of a vapour bubble on a heating element immersed in a liquid which is at saturation temperature or subcooled far from the heating surface but which is superheated near the heating surface, is treated as a problem of heat conduction with evaporation on a boundary. The results show, in agreement with experiment, that in a liquid at saturation temperature the radius grows as $t^{1/2}$ at first (t is time) and as $t^{1/4}$ for $t \to \infty$; for a subcooled liquid the radius as a function of time is given as an infinite series in terms of a quantity H, later identified with the thickness of the thermal boundary layer. Several relations between boundary layer thickness in a boiling liquid, maximum radius attained by the cavity before collapse and superheat and subcooling are derived and compared with experiment. For large subcooling the boundary layer thickness is shown to be about one-half (or less) the size of the maximum radius. Physical considerations concerning the mechanism of heat transmission to a boiling liquid lead to the definition of a heat diffusivity, the exchange diffusivity $a^* = M^2 a$, with M the dimensionless ratio of enthalpies of superheated liquid and of saturated vapour. The dimension of the thermal boundary layer is shown to be the diffusion length for the exchange diffusivity.

5376 ON THE ASYMPTOTIC GROWTH RATE OF VAPOUR BUBBLES IN SUPERHEATED BINARY LIQUID MIXTURES.

P.J.Bruijn.
Physica (Netherlands), Vol. 26, No. 5, 326-34 (May, 1960).

Growth of vapour bubbles in boiling liquid mixtures is slowed by the difference between the vapour composition and the liquid composition if the constituents of the mixture have different volatilities. As the more volatile component is more rapidly exhausted in the liquid near a vapour bubble than the less volatile component, the growth rate of the bubble depends on the supply of the more volatile component by diffusion. Assuming that the radius R of a vapour bubble increases with the time t as $R = C\sqrt{t}$, the growth rate constant C is calculated as a function of the composition for the binary mixtures water—1-butanol, water—ethanol and water—acetone boiling under atmospheric pressure. The problem is of special importance as it has empirically been found that a low growth rate often corresponds to a high value of the coefficient of heat transfer.

5377 VAPORIZATION OF A THIN FILM OF LIQUID IN HIGH VACUUM.

E.Ruckenstein.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 1, 25-39 (Jan.-March, 1957). In Roumanian.

A theoretical study of the evaporation from a thin film of liquid containing several constituents, flowing over a vertical surface. Equations for the dependence of the rate of flow of each constituent on the distance from the point of entry are set up and solved. The case of undulating flow is also discussed. J.Dutton

RECENT ADVANCES OF DISTILLATION TECHNIQUES. See Abstr. 5363

5378 A MASS-SPECTROMETRIC STUDY OF SUBLIMATION OF BERYLLIUM CHLORIDE.

L.N.Ryabchikov and G.F.Tikhinskii.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 635-6 (Oct., 1960). In Russian.

A mass-spectrometric analysis of beryllium chloride vapour escaping from a Knudsen cell at 496°-578° K showed the presence of $BeCl_2^+$, $BeCl^+$, $Be_2Cl_3^+$, $Be_2Cl_4^+$, Be^+, Cl^+, Cl_2^+ and HCl^+ (the latter were due to hydrolysis of beryllium chloride during transfer and to loading of the mass-spectrometer). The heat of sublimation and the energy of dissociation of Be_2Cl_4 were 44 ± 1 and 24 ± 2 kcal/mole, respectively. The heat of sublimation of $BeCl_2$ was 34 ± 1 kcal/mole. A.Tybulewicz

5379 A CRITICAL TEMPERATURE IN CONDENSATION OF Bi, Pb AND Sn.

L.S.Palatnik and Yu.F.Komnik.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 632-3 (Oct., 1960). In Russian.

Bismuth, lead and tin vapours were condensed on heated glass plates in vacuum. Above a certain critical temperature of the glass substrate, these elements were deposited initially as liquid drops followed by solid particles at a later stage. Below the critical temperature, the vapours were always deposited as solid particles. The critical temperatures were 370, 413 and 348° K for bismuth, lead and tin respectively. A.Tybulewicz

5380 APPARATUS FOR MEASURING DEW POINTS BELOW −86° C.

M.J.Fraser and H.W.Weart.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 221-2 (Feb., 1961).

Full details are given of an apparatus suitable for measuring dew points to −190° C. Nitrogen evaporated from the liquid is used as the coolant. Observations on the formation of the solid condensate and accuracy of determination are given. E.G.Knowles

5381 A NEW DETERMINATION OF THE FREEZING POINT OF PURE GOLD.

A.N.Gordov, A.S.Arzhanov and U.V.Diikov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 811-12 (Aug. 1, 1960). In Russian.

Precision nitrogen gas-thermometer measurements at the Mendeleev All-Union Metrology Research Institute gave a weighted mean of 1064.54 ± 0.13° C. [English translation in: Soviet Physics —Doklady (USA), Vol. 5, No. 4, 871-2 (Jan.-Feb., 1961)]. A.Tybulewicz

MELTING POINT OF Al AND Cu. PRESSURE DEPENDENCE. See Abstr. 5134

THERMODYNAMICS

(See also Statistical Mechanics)

5382 A SKETCH FOR A HISTORY OF EARLY THERMODYNAMICS.

E.Mendoza.
Phys. Today (USA), Vol. 14, No. 2, 32-42 (Feb., 1961).

5383 OPERATIONAL FORMULATION OF THE SECOND LAW OF THERMODYNAMICS.

J.S.Thomsen.
Amer. J. Phys., Vol. 29, No. 5, 300-7 (May, 1961).

Various forms of the second law are discussed from the viewpoint of what is necessary to provide a direct experimental proof of the postulates. A new formulation is presented in the form of three axioms, not involving the usual notions of quasi-static processes and cyclic engines on the one hand or adiabatic inaccessibility on the other. Definitions of absolute temperature and entropy are given, and necessary theorems proved in order to derive the usual thermodynamic results. The method is shown to be substantially equivalent to the usual ones; the advantages of the various formulations are discussed. It is noted that the concept of absolute temperature may be derived from a weaker postulate than the second law.

LOW-TEMPERATURE PHYSICS

5384 A HELIUM CRYOSTAT WITHOUT LIQUID NITROGEN COOLING.

A.B.Fradkov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 829-30 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 19571 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 888-9 (Jan.-Feb., 1961)].

Liquid and Solid Helium

FLOW PROPERTIES OF SUPERFLUID SYSTEMS OF FERMIONS. See Abstr. 5235

5385 SOME NOTES ON THEORIES OF HELIUM.

F.J.Pearson.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 531-49 (Feb., 1961).

Attention is directed to that approximation to the quantum-mechanical partition function for an imperfect fluid which is afforded by assuming the commutation of the kinetic and potential energy operators. The corresponding grand partition function is developed in the form of a cluster integral series, and discussion of its behaviour at low temperature is facilitated by a further approximation. This leads to equations for the pressure and density which are similar to the classical expressions of Mayer, and which afford a qualitative description of the condensation of helium into liquids I and II.

Numerical calculation shows not unreasonable agreement with experiment. Finally the theories of Chester and Feynman are discussed in more detail in relation to these cluster integral expansions.

5386 THE MECHANOCALORIC EFFECT IN LIQUID HELIUM ABOVE 0.3°K.

G.J.C.Bots and M.J.F.J.Coremans.
Physica (Netherlands), Vol. 26, No. 5, 342-7 (May, 1960).

Measurements were made on the mechanocaloric effect in liquid helium down to about 0.4°K. A calorimeter partly filled with 20 g of a paramagnetic salt and 9 cm^3 of liquid helium was connected by means of a superleak to a metal bellows which was totally filled with liquid. By changing the volume of the bellows superfluid helium could be made to flow into or out of the calorimeter causing a cooling or heating respectively. Changes in temperature were of the order of a few hundredths of a degree for a flow of about 1 cm^3. The results are compared with values derived from H. London's formula making use of the specific heat data of Kramers and Wiebes. The agreement is good. At temperatures below 0.8°K an extra heat capacity was found in the calorimeter as was already observed by Wiebes et al in their experiments on the specific heat of liquid helium. The results of measurements above 1°K are also in good agreement with theory.

5387 SOME REMARKS ON THE EXTRA HEAT CAPACITY OF A VESSEL CONTAINING LIQUID HELIUM AND A PARAMAGNETIC SALT.

J.M.Reynolds, G.J.C.Bots and M.J.F. J.Coremans.
Physica (Netherlands), Vol. 26, No. 5, 348-50 (May, 1960).

The extra absorption of heat, which occurred in the experiments on the mechanocaloric effect and had been found earlier by Wiebes, Niels-Hakkenberg and Kramers (Abstr. 8562 of 1957) in their investigation of the specific heat of liquid helium, is discussed.

5388 SOME EXPERIMENTAL ASPECTS OF THE FLOW PROPERTIES OF LIQUID HELIUM II. H.C.Kramers.

Suppl. to Physica (Netherlands), Vol. 26, S81-S88 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The two-fluid model is outlined. Measurements of critical velocity and the mutual friction of the two fluids are discussed. Some experiments on vortex lines are described. D.J.Thouless

5389 FOREIGN PARTICLES IN LIQUID HELIUM II. G.Careri.

Suppl. to Physica (Netherlands), Vol. 26, S89-S93 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). Some theoretical problems raised by experiments with impurities in liquid helium are discussed. Cold neutrons have been used to measure the excitation spectrum: the temperature dependence and spreading of the spectrum suggest an interaction distance of 25 A between rotons. The equilibrium properties of solutions of He^3 in liquid helium are understood, but transport properties are not. The effective mass and the interaction cross-section have been measured. The properties of helium ions and of negative charges are compared. It appears that electrons can be bound in vortex lines. D.J.Thouless

5390 HEAT FLUSH AND MOBILITY OF ELECTRIC CHARGES IN LIQUID HELIUM. II. TURBULENT FLOW.

G.Careri, F.Scaramuzzi and J.O.Thomson.
Nuovo Cimento (Italy), Vol. 18, No. 5, 957-66 (Dec. 1, 1960).

For Pt I, see Abstr. 10929 of 1959. The effect of a counterflow of normal and superfluids in liquid helium II on a beam of ions across a wide channel is studied. When a critical value of the heat current is reached a beam of negative ions is strongly affected. This is ascribed to turbulence in the superfluid component and to a strong interaction between the negative ions and the vorticity as vortex lines. The positive ions are instead almost unaffected. The different behaviour of the two types of ions is discussed in terms of their structures.

5391 GENERALIZED B.C.S. STATES AND ALIGNED ORBITAL ANGULAR MOMENTUM IN THE PROPOSED LOW-TEMPERATURE PHASE OF LIQUID ^{3}He. P.W.Anderson.

Suppl. to Physica (Netherlands), Vol. 26, S137-S142 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). A phase transition in liquid He^3 due to the attractive D-state interaction has been predicted at 0.05° K. This phase is similar to the superconducting phase of a metal, but with a lower angular symmetry. The state with the highest possible magnetic quantum number is always the lowest in energy of the axially symmetric solutions of the energy gap equations. The dependence of the energy spectrum on the angular momentum of the interaction that causes the transition is discussed; only for an S-state interaction is there a true energy gap. There is a permanent rotation in such states, and so there should always be small surface currents. The change in symmetry at the phase transition is compared with the ferromagnetic phase transition. The superfluid properties are slightly altered by the anisotropic energy gap. It is remarked that impurities in He^3 should inhibit the phase transition, and that there should be spin-waves in the superfluid phase. D.J.Thouless

5392 NUCLEAR PARAMAGNETIC SUSCEPTIBILITY OF LOW-TEMPERATURE He^3 AND THE FLOW PROPERTIES OF SUPERFLUID SYSTEMS OF FERMIONS. R.M.Rockmore.

Phys. Rev. Letters (USA), Vol. 6, No. 4, 166-7 (Feb. 15, 1961).

Following the work of Nosanow and Vasudevan (Abstr. 2919 of 1961), it is shown that the susceptibility in the low-temperature phase gives a direct measure of the effective mass, when combined with moment of inertia measurements. R.G.Chambers

5393 RECALCULATIONS ON EARLIER EXPERIMENTS ON THE FOUNTAIN EFFECT BELOW 1°K.

G.J.C.Bots and C.J.Gorter.
Physica (Netherlands), Vol. 26, No. 5, 337-41 (May, 1960).

Recalculations especially with respect to the determination of temperature are made on the earlier published measurements of the fountain effect below 1°K (Abstr. 6566 of 1956) making use of new data on the magnetic properties of chromium potassium alum which is now available. Introducing these new data the small discrepancy which was found below 0.7°K between the experimental results and the corresponding theoretical values derived from the entropy data with the aid of H. London's formula has disappeared.

Superconductivity

5394 RECENT ADVANCES IN THE THEORY OF SUPERCONDUCTIVITY. J.R.Schrieffer.

Suppl. to Physica (Netherlands), Vol. 26, S124-S136 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The general features of the excitation spectrum in normal and superconducting metals are compared. The independent quasi-particle approximation and the random phase approximation for collective modes are developed. It is shown that in the limit of low momentum the equations are rotation invariant, and the modes can be separated into angular momentum components. An attractive interaction brings these collective modes, "excitons", below the energy gap; only the angular momentum zero exciton is destroyed by the long-range Coulomb force. The dependence of an exciton energy on momentum is sketched. The four-component theory for quasi-particles is developed, and it is shown how an improved energy gap equation can be found by Green's function methods. D.J.Thouless

5395 TUNNELLING FROM A MANY-PARTICLE POINT OF VIEW. J.Bardeen.

Phys. Rev. Letters (USA), Vol. 6, No. 2, 57-9 (Jan. 15, 1961).

The tunnelling of electrons through a potential barrier separating two conductors is shown to depend on the matrix element of current in the barrier and on the final density of states. The matrix element is unaffected when one metal becomes superconducting, because electrons in the barrier remain unpaired, so that the tunnel current depends simply on the changed density of states, as found by Giaever (Abstr. 16949 of 1960). R.G.Chambers

5396 THE QUASI-PARTICLE APPROXIMATION IN SUPERCONDUCTIVITY. P.G.Harper.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 299-302 (Feb., 1961).

A derivation of the Bardeen, Cooper and Schrieffer and the Bogolyubov secular equations by a common method shows that it is necessary to neglect a large number (proportional to V^n) of small matrix elements (proportional to V^{-n}), where V is the volume of the system and n an arbitrary positive integer. A generalization of the Bogolyubov fermion transformation, with diagonalizes these terms, takes the form of an infinite series whose convergence may depend on the form of the interaction.

5397 ON THE PHASE TRANSITION OF A SUPERCONDUCTOR.
G.Wentzel.
Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 859-71 (1960).

In previous studies of the statistical mechanics of a superconductor, only the "reduced Hamiltonian" of the B.C.S. theory has been used which ignores the vast majority of the electron—electron interactions. Here, the Hamiltonian is extended by including the other interactions as perturbations up to the second order. As a preliminary step, omitting all but the first-order terms in the Hamiltonian, a rigorous expression for the free energy is derived. Then, to take account of the second-order perturbations, a variational method is used. Particular attention is paid to the behaviour of the free energy near the critical temperature. Effects of the lattice periodicity are not examined.

5398 THE VOLUME DEPENDENCE OF THE ELECTRON LEVEL DENSITY AND THE CRITICAL TEMPERATURE IN SUPERCONDUCTORS. J.L.Olsen and H.Rohrer.
Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 872-80 (1960).

Experimental work on the volume dependence of the critical magnetic field in superconductors, and on the volume change at the transition is summarized and discussed. The best values for $d \ln T_c/d \ln v$ and $d \ln \gamma/d \ln v$ (T_c = transition temperature, γT = electronic specific heat per mole, v = molar volume) are estimated. $d \ln \gamma/d \ln v$ is many times greater than the free electron value. No correlation between $d \ln T_c/d \ln v$ and $d \ln \gamma/d \ln v$ could be seen, but the relation $d \ln(T_c/\theta)\, d \ln v \approx \text{const.}$ $\ln(\theta/T_c)$ is approximately obeyed for the soft superconductors (θ = Debye temperature).

THERMAL CONDUCTIVITY OF SUPERCONDUCTORS IN THE INTERMEDIATE STATE. See Abstr. 4973

ON THE "NEW TAMM—DANCOFF" APPROXIMATION TREATMENT OF THE SUPERCONDUCTIVITY HAMILTONIAN.
See Abstr.5694

THE SUPERCONDUCTING TRANSITION IN LANTHANUM.
See Abstr. 5003

5399 SUPERCONDUCTIVITY IN Nb_3Sn AT HIGH CURRENT DENSITY IN A MAGNETIC FIELD OF 88 KGAUSS.
J.E.Kunzler, E.Buehler, F.S.L.Hsu and J.H.Wernick.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 89-91 (Feb. 1, 1961).

Nb_3Sn rods about 0.4 mm thick carried currents up to about 5 A at 1.5°K without showing measurable resistance, in a transverse field of 88 kG. Rods 0.15 mm thick, encased in Nb, carried currents of 2 - 30 A, depending on method of preparation.
R.G.Chambers

5400 SUPERCONDUCTORS AS QUANTUM DETECTORS FOR MICROWAVE AND SUB-MILLIMETER-WAVE RADIATION. E.Burstein, D.N.Langenberg and B.N.Taylor.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 92-4 (Feb. 1, 1961).

It is suggested that the tunnel current in the Giaever experiment (Abstr. 16949 of 1960) may be altered by optical excitation of carriers across the energy gap, as in a p—n junction. Such a photo-detector would have a long wavelength limit of order 1 mm.
R.G.Chambers

5401 EXPERIMENTS ON THE ANGULAR MOMENTUM OF A SUPERCURRENT AND THE POSSIBILITY OF A SUPERCURRENT GYROSCOPE. A.C.Rose-Innes and G.M.Taylor.
Amer. J. Phys., Vol. 29, No. 4, 268-71 (April, 1961).

It is shown experimentally that the direction of the angular momentum of a circulating supercurrent remains fixed relative to the body in which the current flows. It is not, therefore, possible to make a gyroscope which uses the angular momentum of a circulating supercurrent. The influence of an external magnetic field on the direction of the angular momentum has also been studied.

ELECTRICITY
ELECTRICAL MEASUREMENTS AND CIRCUITS

RELATIVITY OF MOVING CIRCUITS AND MAGNETS.
See Abstr. 5189

5402 A KILOVOLT, KILOAMPERE LOW PRESSURE SWITCH.
G.J.Brucker and K.C.Rogers.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 236-8 (Aug., 1960).

A low-pressure switch is described that is capable of passing kiloamperes at voltages up to 30 kV. The effect of pressure and gap voltage on the switch closing time is discussed. The device was developed for switching the capacitor bank current to the field coil of the megatron accelerator at the Stevens Institute of Technology, New Jersey.

5403 A CIRCUIT FOR CURRENT STABILIZATION DURING THE MEASUREMENT OF CHANGES IN WORK FUNCTION.
G.Comşa, A.Gelberg, A.Georgescu and V.Grabari.
Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 445-50 (1958).
In Roumanian.

Changes of work function are compensated by changes in the applied potentials. Currents of 10^{-7}-10^{-9}A can be stabilized to an overall accuracy of better than 0.3%.
A.H.W.Beck

5404 A NON-LINEAR STUDY OF THE PARALLEL INTEGRATOR [CIRCUIT] USING A FIRST-ORDER [ALGEBRAIC] APPROXIMATION. J.Lagasse and C.Mira.
C.R. Acad. Sci. (France), Vol. 251, No. 21, 2314-16 (Nov. 21, 1960).
In French.

It is shown that over a limited range of variables and parameters the equation of a parallel integrator, which has a solution with a pole close to the origin in the complex plane, may be solved by a first-order approximation.
S.A.Ahern

5405 CHARACTERISTICS TRACER.
P.G.Guest.
Amer. J. Phys., Vol. 29, No. 5, 287-91 (May, 1961).

Details are given of a circuit which may be used in lecture demonstrations and undergraduate laboratory classes to display on an oscillograph the characteristic curves of both valves and transistors.

5406 AN ELECTRONIC COUNTER WITH A LARGE DISPLAY FOR DEMONSTRATION EXPERIMENTS.
G.Horn, G.Sauerbrey and K.Tradowsky.
Z. angew. Phys. (Germany), Vol. 12, No. 12, 576-9 (Dec., 1960).
In German.

The counter is a normal 5-decade instrument connected by buffer valves and relays to a 5-column, 10-line array of lamps. Applications to counting in nuclear physics, time measurement and measurement of velocities are described.
W.G.Stripp

5407 ELECTRONICS FOR HANDLING RANDOM EVENTS.
D.G.Maeder.
Energia nucleare (Italy), Vol. 8, No. 1, 16-28 (Jan., 1961).

The randomness of pulses produced by nuclear detectors and the problems which electronics have to face when handling such kind of pulses are taken into consideration. The two following problems: (a) analysis of the random time distribution, (b) analysis of the random pulse height distribution, are examined. The outstanding aspects of instruments and electronics circuits, needed to analyse such pulses, i.e. (a) oscilloscopes, short time intervals measuring circuits, triggers and counters (for time measurements); (b) linear amplifiers, pulse height analysers, storage techniques (for pulse height measurements), are reviewed.

5408 DETERMINATION OF RANDOM COINCIDENCES IN FAST—SLOW COINCIDENCE CIRCUITS.
T.Mayer-Kuckuk and R.Nierhaus.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 76-8 (July, 1960). In German.

In some applications of fast—slow coincidence circuits the random coincidence rate is not small compared with the true coinidence rate. In such cases it is usually necessary to correct for andom coincidences. The random coincidence rate is considered s consisting of four parts, the first part corresponding to three andomly coincident pulses at the inputs of the slow triple coinidence circuit, the other parts corresponding to the three possibilies of true coincidences between two pulses at two inputs randomly oincident with a pulse on the third input of the slow circuit. The our parts can be determined separately either by calculation using easured coincidence resolving times, or by counting with delay nes before the inputs of the slow coincidence circuit. The deterination of random coincidences only by using a delaying cable efore one input of the fast coincidence circuit does not appear ppropriate.

5409 SIMPLE MILLIMICROSECOND PULSE GENERATOR.
H.S.Caplan and D.T.Stewart.
. sci. Instrum. (GB), Vol. 38, No. 4, 133 (April, 1961).

Describes a hydrogen discharge pulse generator, and gives an pplication of it to nuclear scintillation counter techniques.

5410 LENGTHENING CIRCUIT FOR RAPID PULSES.
A.Sarazin, J.Samueli, G.Ducros and P.Raimbault.
uclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 70-2 (July, 960). In French.

A pulse lengthener is described for use with a multichannel nalyser, in order to study the amplitude of pulses in the nanosecond ange. The circuit is linear from 0.8 to 14 V and its recovery time s 0.5 μsec.

5411 NONLINEAR OPERATIONS ON PULSES BY MEANS OF P—N JUNCTIONS. G.Giannelli and L.Stanchi.
uclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 79-91 July, 1960).

A study of the voltage—current characteristics of p—n junctions s described. It was found that by suitable use of a transistor, its mitter-base junction shows a characteric that approximates the heoretical one much better than diodes do. In particular some types f transistors were found whose i_E, v_{EB} characteristic is strictly ogarithmic over more than five decades of current while selected amples attain six decades. The use of such junctions for multilying or dividing between them two or more pulses is described and he various problems arising in such application and in more general nes, like exponentials, are analysed.

5412 A SINGLE CHANNEL TIME ANALYSER FOR THE SPECTROMETRY OF FAST PARTICLES BY MEANS OF TIME-OF-FLIGHT TECHNIQUES IN THE NANOSECOND REGION.
N.Martalogu, F.Ţintă, R.Dumitrescu, I.Korgueva and M.Molea.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 515-32 (1959). n Roumanian.

The general design of a retarded coincidence analyser is desribed and the conditions and performance of the spectrometer are llustrated by several characteristic curves. With constant ampliude pulses as well as with light pulses in auto-coincidence an intrinic resolution time of 2.5×10^{-11} sec with an efficiency of 100% is laimed. Under normal operating conditions a 100% efficiency is chieved with a resolution time of 2.1×10^{-10} sec and a sensitivity f 0.2 to 0.3 V. S.J.St-Lorant

ELECTROSTATICS . DIELECTRICS

(The study of solids through their dielectric properties is included under Solid-State Physics; similarly for Liquid State and Gaseous State)

5413 PROGRESS IN DIELECTRICS. VOLUME 2.
Edited by J.B.Birks and J.H.Schulman.
ondon: Heywood (1960) 225 + vii pp.

For Vol. I, see Abstr. 6868 of 1959. This second volume ontains a preface and six review articles. Abstracts of the rticles will appear in this or subsequent issues of Physics bstracts. J.B.Birks

5414 PROGRESS IN DIELECTRICS. VOLUME 3.
Edited by J.B.Birks and J.Hart.
London: Heywood (1961) 292 + vii pp.

This volume contains a preface and six review articles. Abstracts of some of the articles will appear in this or subsequent issues of Physics Abstracts. J.B.Birks

CALCULATION OF ELECTROSTATIC POTENTIALS. See Abstr. 5114

5415 CORRECTION TERM FOR DIELECTRIC MEASUREMENTS WITH CAVITY RESONATORS. E.S.Hotston.
J. sci. Instrum. (GB), Vol. 38, No. 4, 130-1 (April, 1961).

The effect of varying the diameter of a polystyrene disk on the value of its dielectric constant when measured in a resonator of fixed diameter is investigated. Agreement is obtained with results predicted by perturbation theory.

5416 ELECTROSTATIC ATTRACTION BETWEEN A LIQUID SURFACE AND A NEEDLE HEIGHT-GAUGE.
A.T.J.Hayward.
Nature (GB), Vol. 188, 927 (Dec. 10, 1960).

During measurement of position of the surface of a mineral oil, contained in a Perspex vessel, by means of a measuring point, it was found that when the metal point was brought to about 0.05 in. above the oil surface a rhythmic disturbance of the oil occurred. It is suggested that this effect is due to electrostatic charge on the surface of the oil causing attraction towards the point resulting in a hump on the oil surface. The charge on the oil at this point is then removed by the lightning-conductor action of the needle point, whereupon the hump collapses, reforming as fresh charges enter the discharged area from the surrounding surface. If the needle is closer than this, the hump touches the needle point, is held there by surface tension and an error results in the reading of position. The effect can be eliminated by means of an earth wire attached to the needle, the end of the wire being bent upwards so that it faces the needle point at a distance of 0.1 in. In this way any charges in the liquid near the needle point are removed. T.C.Toye

LOW-INDUCTANCE CAPACITOR BANKS. See Abstr. 5476

CURRENT ELECTRICITY ELECTROKINETICS

(The study of solids through their electrical conduction properties is included under Solid-State Physics)

5417 FLUCTUATION PHENOMENA IN ELECTRICAL CONDUCTION IN SOLID BODIES. H.Bittel.
Ergeb. exakt. Naturwiss. (Germany), Vol. 31, 84-166 (1959). In German.

Review article. Thermal noise; Designation of electrical fluctuation magnitudes; Corpuscular treatment of thermal noise; Measurement of current noise; Noise of carbon resistances; Current noise of semiconductors; noise of metallic conductors; Hypotheses on the origin of 1/f noise.

IONIZATION

5418 INTERPRETATION OF THE APPEARANCE POTENTIALS OF SECONDARY IONS.
M.B.Wallenstein and M.Krauss.
J. chem. Phys. (USA), Vol. 34, No. 3, 929-36 (March, 1961).

The statistical theory of mass spectra assumes that the excitation energy in a molecule-ion is essentially equipartitioned prior to unimolecular decomposition. Some of the consequences of this assumption are deduced and the results used in interpreting the observed appearance potentials of secondary and tertiary ions of neopentane, n-butane, and 1-butane. Although the results are not quantitative, it is evident that considerable vibrational energy is removed with the neutral fragment. The problem of the detailed interpretation of appearance potentials is complicated by the fluctuation of the vibrational energy distribution in the products of a decomposition from the most probable value, i.e., equipartition. Some general considerations with regard to determination of minimum-energy decomposition paths and the significance of this study in relation to the statistical theory of mass spectra are also presented.

5419 ESTIMATION OF INELASTIC COLLISION CROSS SECTION FROM ELECTRON MOBILITY MEASUREMENTS. M.S.Sodha.

Proc. Phys. Soc. (GB), Vol. 76, Pt 3, 439-41 (Sept., 1960).

A parametric relation is derived between the mobility of electrons and the applied electric field in a slightly ionized gas. This relation can be used to estimate the inelastic collision cross-section from the observed variation of mobility with the field. The following assumptions were made which limit the applicability of the method: (1) the inelastic collisions in which the electron gains energy from the field are not considered; (2) the cross-sections for both elastic and inelastic collisions are proportional to a power of velocity; (3) the velocity distribution of the electrons is Maxwellian, corresponding to a temperature higher than that of the gas. M.S.Sodha

5420 COLLISIONAL DETACHMENT IN MOLECULAR OXYGEN. A.V.Phelps and J.L.Pack.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 111-13 (Feb. 1, 1961).

Measurements by a pulse method of attachment and detachment coefficients in molecular oxygen as a function of temperature lead to a value of 0.46 ± 0.02 eV for the electron affinity of the negative ion formed. This value is three times that used in the analysis of recent photo-detachment experiments (Abstr. 3607 of 1959). The results also lead to a calculated collisional detachment coefficient at 230^0K of 4×10^{-20} cm^3 sec^{-1} compared with values of about 10^{-17} cm^3 sec^{-1} usually used in the analysis of ionospheric data [Bailey and Branscomb, Bull. Amer. Phys. Soc., Vol. 5, 123 (1960)]. J.Dutton

5421 THERMAL IONIZATION AND ELECTRICAL CONDUCTIVITY IN MIXTURES OF GASES. Yu.V.Sanochkin.

Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 188-93 (Feb., 1961). In Russian.

Magnetohydrodynamic problems demand knowledge of the ionization and the electrical conductivity of gases heated to a high temperature. This is considered for mixtures of monatomic gases, taking account of first and subsequent ionizations. Basic to this is a simple application of the law of mass action, the relative amounts of particles ionized k-times depending in a known way on temperature. It is made clear that proper choice of gas mixtures can provide any desired degree of ionization for a given temperature range. By way of example, the degree of ionization attending a shock wave propagated through argon is investigated. The dependence of the electrical conductivity on temperature and Mach number is deduced. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5422 VELOCITY OF PROPAGATION OF THE IONIZATION FRONT ON BREAKDOWN IN DISCHARGE TUBES.

A.V.Nedospasov and A.E.Novik.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 11, 1329-36 (Nov., 1960). In Russian.

Reports an experimental investigation of the ionization front propagated down a long gas-discharge tube subjected to a voltage which changes at 10^5-10^6 volt/sec. The velocity of propagation depends closely not only on the nature and pressure of the gas, but also on the dimensions of the tube and the rate of change of the applied voltage. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 11, 1261-7 (May, 1961)]. A.E.I.Research Laboratory

5423 ON THE TOTAL SPECIFIC IONIZATION.

P.Budini, L.Taffara and C.Viola.

Nuovo Cimento (Italy), Vol. 18, No. 5, 864-83 (Dec. 1, 1960).

A method is given for calculating the absolute value of primary, secondary and total specific ionization generated by a ionizing particle traversing a given medium. Density effect is taken into account. Numerical results are given for H and He and compared with existing experimental data. It is shown that primary ionization presents higher relativistic increase (lower density effect), than the total one where the dilution of secondary ionization is felt. Further primary ionization is independent of maximum transferable energy in close collisions which on the contrary influences sensibly ionization of higher generations. Simplified formulae are given where the influence of the physical characteristic of the medium on the phenomenon appears evident and which have to be compared with experimental results.

5424 CAPACITIVE ENERGY AND THE IONIZATION OF AROMATIC HYDROCARBONS. F.T.Smith.

J. chem. Phys. (USA), Vol. 34, No. 3, 793-801 (March, 1961).

Large polynuclear aromatic molecules ionize like fragments of graphite, and their ionization potentials approach the sum of the graphite work function v_{gr} and the electrostatic work of charging a conductor the size and shape of the molecule. The capacitive work for a single charge is $u = e^2/2C$, where C is the molecular capacitance. In the limit of large size, the work to remove n electrons is $W_n = nv_{gr} + n^2u$. This limiting law implies a relation among successive ionization potentials and the electron affinity, which is well satisfied by anthracene and phenanthrene, and moderately well by naphthalene and even benzene. For larger molecules, C, and therefore u, can be estimated classically by assuming the conducting region is bounded by the carbon skeleton, and computed by analogue measurements on metallic models; results are tabulated for a series of aromatics. The relation between the limiting law and more detailed quantal formulations is discussed, and the magnitude and trend of some expected deviations are explored with the help of a simple free electron picture.

ELECTRIC DISCHARGES

5425 VARIATIONS IN THE CONSTANTS OF AN OSCILLATING CIRCUIT COUPLED WITH AN IONIZED GAS (H,Ne).

P.Ştiubei.

Stud. Cercetari. Fiz. (Roumania), Vol. 10, No. 3, 505-13 (1959). In Roumanian.

Experimental study of O, H and Ne h.f. gas discharges around 60 Mc/s. In O and H the h.f. energy absorption goes through a maximum as the d.c. current is increased. In Ne no maximum is observed. This is supposed to be due to negative ions. The determining characteristic is independent of the nature of the gas but changes sign as the d.c. current increases above a certain low figure. A.H.W.Beck

5426 SUSTAINED, LOCALIZED, PULSED-MICROWAVE DISCHARGE IN AIR. C.W.Hamilton.

Nature (GB), Vol. 188, 1098-9 (Dec. 24, 1960).

Describes an electrodeless discharge in low-pressure air (0.3 mm to 47 mm) sustained at the focus of a pulsed, X-band microwave beam. It was observed that the shape and colour of the discharge were affected by such factors as the air pressure and the disposition of the beam focus with respect to the walls of the containing glass chamber. Unless the discharge was caused to contact the walls, no noticeable temperature rise in the chamber occurred. G.Carter

5427 PROPAGATION OF A DISCHARGE IN SINGLE CRYSTALS OF NaCl and KCl.

A.A.Vorob'ev, G.A.Vorob'ev and M.A.Mel'nikov.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2019-24 (Sept., 1960). In Russian.

For abstract, see Abstr. 19632 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1814-18 (March, 1961)].

5428 LIMITING BRIGHTNESS OF THE SPARK DISCHARGE CHANNEL. M.P.Vanyukov, A.A.Mak and A.I.Sadykova.

Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 557-9 (Nov. 21, 1960). In Russian.

Briefly describes measurements of the limiting brightness in discharges in helium, nitrogen and argon in the spectral range 2300-9000 A for currents of 10^{12} A/sec rise time. Brightness was measured by optical spectroscopy on selected lines. The results are in good agreement with theory. [English translation in: Soviet Physics—Doklady (USA)]. A.E.I.Research Laboratory

5429 NEW MATERIAL ON THE DEVELOPMENT OF THE CHANNEL OF A LONG SPARK.

I.S.Stekol'nikov and A.V.Shkilev.

Dokl. Akad. Nauk SSSR, Vol. 136, No. 4, 803-6 (Feb. 1, 1961). In Russian.

The behaviour of a rod-to-plane spark discharge is observed

imultaneously by means of a high-speed oscillograph, an electron ptical image converter, and high-speed photography. The discharge s seen to develop in jumps, simultaneous ionization taking place ver discrete sections of the "leader" channel. To a certain extent e manner in which a spark develops depends on the previous parking history of the gap. [English translation in: Soviet Physics—oklady (USA)].
A.E.I. Research Laboratory

5430 BROADENING OF THE SPARK CHANNEL IN LIQUIDS.
Yu.V.Skvortsov, V.S.Komel'kov and N.M.Kuznetsov.
h. tekh. Fiz. (USSR), Vol. 30, No. 10, 1165-77 (Oct., 1960). In ussian.

The initial stages of broadening of a powerful discharge in ater were investigated. Currents of 7.5×10^5 A and rate of rise f 2×10^{11} amp/sec were used. The speed of broadening and the elocity of the shock wave were measured. An estimate is given f the conductivity and current density in the discharge. A hydroynamical calculation is included of the pressure and velocity of ropagation of the shock-wave front. [English translation in: Soviet hysics—Technical Physics, Vol. 5, No. 10, 1100-12 (April, 1961)].
A.E.I. Research Laboratory

5431 INVESTIGATION OF THE POSITIVE COLUMN OF THE DISCHARGE IN A MIXTURE OF MERCURY AND NEON.
.I.Vavilin, S.D.Vagner, V.K.Lanenkina and S.S.Mitrofanova.
h. tekh. Fiz. (USSR), Vol. 30, No. 9, 1064-6 (Sept., 1960). In ussian.

Existing theories suggest that ions in the given mixture will be roadly separated into two parts: the metal ions near the cathode, he inert-gas ions near the anode. Measurement shows however that significant proportion of neon ions exist along with the mercury at he cathode. The variation of this behaviour with discharge current s examined. [English translation in: Soviet Physics—Technical hysics (USA), Vol. 5, No. 9, 996-8 (March, 1961)].
A.E.I.Research Laboratory

5432 MOVING STRIATIONS AND ANODE SPOTS IN NEON.
J.R.M.Coulter, N.H.K.Armstrong and K.G.Emeleus.
roc. Phys. Soc. (GB), Vol. 77, Pt 2, 476-82 (Feb., 1961).

An experimental study was made of boundary conditions at the ositive end of positive columns in a glow discharge in neon which ere traversed by waves of ionization (moving striations) proceeding owards the Faraday dark space. The striations were generated rom small anode spots, which usually oscillated with increasing mplitude until they became detached from the anode. Closely simlar processes took place at the negative end of a capillary tube hen the discharge was passed through the capillary into a wide ube. A few typical time-resolved photographs of the oscillations re reproduced to illustrate the nature of the phenomena and their ependence on pressure and current, and possible causes of the scillations are discussed briefly.

5433 THE GLOW-TO-ARC TRANSITION ON EASILY VAPORIZED CATHODES. R.Arndt.
nn. Phys. (Germany), Vol. 7, No. 3-4, 159-78 (1961). In German.

Reports an investigation of the glow-to-arc transition at Cu, g, Ni and Au cathodes for nitrogen high-pressure discharges, and for bnormal helium low-pressure glow discharges on Hg cathodes. he transition can be induced by Cu_2O particles in Cu, by non-niform oxide layers on Cu, Ni and Hg and even by particles of glass. niform oxide layers and hydrogen-loaded Ni and Hg cathodes do ot favour the formation of an arc. It is concluded from the foration of cones on Ag, from the stability of Hg—N_2 compounds and rom experiments with glass fibres on Hg, that even microscopic istortion of the field can produce an arc transition.
H.Edels

5434 ELECTRODE COMPONENTS OF THE ARC DISCHARGE.
G.Ecker.
rgeb. exakt. Naturwiss. (Germany), Vol. 33, 104 pp. (1961).
Review article.

5435 THE INFLUENCE OF THE FLOW OF GAS ON AN ARC BURNING IN A NOZZLE. K.Zückler.
. angew. Phys. (Germany), Vol. 12, No. 12, 567-75 (Dec., 1960).
German.

The subject is directly related to the similar effects occuring switchgear in the current zero period of an alternating current arc. scillographic measurements were made of the gas pressure, voltge and current during the half cycle of arcing produced in a capacity-nductance discharge circuit. The arc burned between carbon lectrodes housed in nozzles. Results are given relating the nozzle cross-sectional area, the resistance to gas flow with the arc present, and the arc power input for different nozzle pressure differences. On the basis of certain assumptions, a theory is given which gives reasonable agreement with experiment.
H.Edels

5436 THE INTAKE OF MATERIALS IN AN ARC DISCHARGE.
A.L.Stolov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 9, 1061-3 (Sept., 1960). In Russian.

Discusses the stability of an arc, which limits the reproducibility of spectral analysis. The stability was investigated for various electrode materials by photographing the discharge and recording the intensity fluctuations on an oscillograph. The fluctuations in the case of Al, Bi, and Pb proved to be marked functions of time. [English translation in Soviet Physics—Technical Physics (USA), Vol. 5, No. 9, 993-5 (March, 1961)].
A.E.I. Research Laboratory

5437 PRE-BREAKDOWN PHENOMENA IN NITROBENZENE BY MEANS OF THE KERR ELECTRO-OPTICAL EFFECT. P.Chong, C.Yamanaka and T.Suita.
Technol. Rep. Osaka Univ. (Japan), Vol. 9, 17-21 (March, 1959).

The field distribution and its lag time in nitrobenzene when d.c. and single pulse voltages are applied was investigated. The apparatus is briefly described. The results showed that for both d.c. and pulse voltages only the cathode field intensity was increased. This increase was 130% of the applied field intensity of 0.267 MV/cm. For the 25 μsec pulses a lag before the field distribution between the electrodes was steady was always observed. This time lag was about 10 μsec for an applied field of 8 KV at room temperature. The authors relate these phenomena to viscosity and deduce that they are caused by the movement of positive ions with an estimated mobility of the order of 10^{-3} cm^2 sec^{-1} V^{-1}.
H.G.Jerrard

SOME RESULTS OF A SPECTROSCOPIC STUDY OF V.H.F. PULSE DISCHARGES IN A RESTRICTED DISCHARGE GAP.
See Abstr. 4907

SOME REMARKS OF ELECTRIC-DISCHARGE SHOCK TUBE DIAGNOSTICS. See Abstr. 5475

PLASMA

(See also Magnetohydrodynamics)

5438 PHYSICS OF PLASMA: EXPERIMENTAL AND TECHNICAL. [Fisica del plasma: esperimente e tecniche]. Edited by H.Alfvén.
Rendiconti della Scuola Internazionale di Fisica Enrico Fermi, Corso XIII. Bologna: Zanchelli (1960) 165 pp.

Lectures given at the Varenna summer school of physics. These lectures are in the main reviews, or further accounts of work published elsewhere; a small amount of original, hitherto unpublished work is embodied. Titles and authors are: Plasma physics, H.Alfvén (1-8); Motion of charged particles in electric and magnetic fields, S.Lundquist (9-14); Particle view compared with hydrodynamics, S.Lundquist (15-19); Runaway phenomena and relaxation effects, S.Lundquist (20-4); Plasma stability, S.Lundquist (25-33); Mercury experiments, S.Lundquist (34-7); Collision-free hydromagnetic waves, J.E.Allen (38-50); Langmuir probes and boundary phenomena, J.E.Allen (51-60); Magnetic confinement and different machines, J.E.Allen (61-8); Fast circuits, J.E.Allen (69-75); The Boltzman equation, H.L.Jordan (76-81); Hydromagnetic shock waves, Pt I. Theory, H.L.Jordan,(82-9); Hydromagnetic shock waves, Pt II. Experiment, H.L.Jordan (90-6); Fast circuit techniques and experments with fast magnetic compression devices, H.L.Jordan (97-106); Coulomb collisions and plasma conductivity, R.J.Bickerton (107-18); Experiments with waves in a plasma, R.J.Bickerton (119-25); Pinch effect, R.J.Bickerton (126-44); Stability experiments, R.J.Bickerton (145-50); Phenomena in plasma-solid boundaries, R.S.Pease (151-7) (an abstract of this paper will be published); Sputtering of solids by penetrating ions, R.S.Pease (158-65).
R.S.Pease

RELATIONS BETWEEN PLASMA PHYSICS AND ASTROPHYSICS. See Abstr. 5150

5439 PLASMA PHYSICS AND THE PROBLEM OF CONTROLLED THERMONUCLEAR REACTIONS. [FOUR VOLUMES]. VOLUMES II-III.

London : Pergamon Press (1959) 457 and 422 pp.

Contains English translations of a selection of articles on the theoretical and experimental investigations carried out at the Institute of Atomic Energy of the U.S.S.R. Academy of Sciences between 1951 and 1958. Abstracts of the individual articles will be published in later issues of Physics Abstracts.

5440 INTERACTION OF A TEST PARTICLE WITH A PLASMA. I. DISTRIBUTION FUNCTION OF FIELD PARTICLES.

A.Ron and G.Kalman.

Ann. Phys. (USA), Vol. 11, No. 2, 240-59 (Oct., 1960).

The distribution function of plasma particles is calculated in the case where a charged test particle travels through the plasma. Conditions for the steady-state solution and the effects of neglecting the interaction between the plasma particles are investigated. These calculations may serve as a starting point to find the coefficients of dynamic processes in plasma

5441 INTERACTION OF AN ELECTRON BEAM WITH A FULLY IONIZED PLASMA.

M A.Allen and G.S.Kino.

Phys. Rev. Letters (USA), Vol. 6, No. 4, 163-5 (Feb. 15, 1961).

Amplification of the microwave signals modulating an electron beam was observed after the beam had passed through a caesium plasma in a magnetic field. The degree of ionization of the plasma was greater than 10%. Theoretical values of the transverse propagation constants are derived and the variation of gain with frequency can be explained using them. The mechanism of the emission of radiation from a stellar surface might also be explained by this theory.

J.W.Sturgess

5442 COOPERATIVE INTERACTIONS IN A PLASMA.

K.M.Watson.

Suppl. to Physica (Netherlands), Vol. 26, S188-S196 (Dec., 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). At typical plasma densities and temperatures, corrections to the ideal gas law are negligible. When the plasma is not in equilibrium, collisions can be neglected, and irreversible effects may be largely due to interactions between plasma waves which produce turbulence. The plasma-wave dispersion law is derived from the Vlasov equation. Streaming instability is evaluated, and is suggested as a mechanism for producing a shock wave.

D.J.Thouless

5443 AN ERROR IN THE THERMAL CONDUCTIVITY FOR A FULLY IONIZED GAS.

R.W.Vaughan-Williams and F.A.Haas.

Phys. Rev. Letters (USA), Vol. 6, No. 4, 165-6 (Feb. 15, 1961).

Corrects an error in the calculations of Marshall [Atomic Energy Res. Establ. (Harwell), Rep. T/R 2419 (1958)] which removes a discrepancy with the results of Rosenbluth and Kaufmann (Abstr. 2421 of 1958).

J.W.Sturgess

5444 THEORY OF THE "RESTORING" LAYER.

V.N.Zhigulev.

Dokl. Akad. Nauk SSSR, Vol. 134, No. 6, 1313-16 (Oct. 21, 1960). In Russian.

The interaction of a free molecular plasma stream with an external magnetic field causes a repulsion of the particles by the field in a localized layer. The boundary between the magnetic field and the plasma stream is called the "restoring" layer inside which the magnetic field increases from zero to some maximum value. The theory of the restoring layer is considered under relativistic conditions when the velocity of motion of the plasma stream is perpendicular to itself. An exact solution is obtained for non-relativistic motion in the "restoring" layer for a plasma with identical charged particles. An approximation is then made for a real plasma (motion of protons and of electrons) when a new mechanism of the electron motion is present. The results are applied to the "restoring" layer round the earth due to the interaction of its magnetic field with particles emanated from the sun. [English translation in: Soviet Physics--Doklady (USA)].

J.K.Skwirzynski

5445 STABILITY OF A PLASMA SHEET IN TIME PERIODIC MAGNETIC FIELDS.

L.Solymar.

J. Electronics and Control (GB), Vol. 9, No. 5, 391-6 (Nov., 1960).

The behaviour of a thin sheet of electrons in a time-varying square-wave magnetic field is investigated. It is shown that the growth of an initial disturbance which takes place in the first half of a period is entirely annulled in the second half, both the displacements and velocities returning to their initial values. It is concluded that the break-up og annular beams in a uniform magnetic field which has been observed should be strongly inhabited in a periodic field.

5446 LONG RANGE FORCES AND THE DIFFUSION COEFFICIENTS OF A PLASMA.

W.B.Thompson and J.Hubbard.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 714-18 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The study of the diffusion coefficients is dogged by the long range nature of the Coulomb force, which usually demands the introductio of a more or less artificial long range cut off in certain integrals occurring in either the Boltzmann, or the Fokker—Planck equation. This cut-off, which represents the screening of charges by the plasma should appear as a consequence of the dielectric effects of the intervening plasma on the interaction of widely separated particles, but a direct treatment is complicated by the radiation of plasma waves from rapidly moving particles. If, however, the diffusion coefficients are expressed in terms of the fluctuating microfield, and the dielectric properties used in calculating the latter quantity, a calculation can be made which avoids the long rang cut-off. The consequence of this will be displayed for a plasma nea thermal equilibrium.

5447 COLLISION BETWEEN A NON-IONIZED GAS AND A MAGNETIZED PLASMA.

H.Alfvén.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 710-13 (Oct., 1961).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). This is a problem of astrophysical importance. If there is a thin plasma in a magnetic field (e.g. near a celestial body), a stream of non-ionized gas hitting this plasma may be ionized at the collision and hence stopped by the magnetic field. An experimental investigation by Block and Fahleson shows that the gas does not get ionized as long as the relative velocity between the non-ionized gas and the plasma is below a certain critical value v_c. When this value is exceeded, a high degree of ionization is suddenly produced. The critical value seems to be given by the condition that the kinetic energy of the atoms should equal the ionization energy. The phenomenon cannot be explained by binary collisions. Probably space charge produced in the plasma is of decisive importance for the transfer of the energy of the atoms to the electrons, which later ionize the atoms.

5448 IRREVERSIBLE PROCESSES IN PLASMAS IN A STRONG MAGNETIC FIELD.

T.Kihara and Y.Midzuno.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 722-30 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The processes are discussed from both the phenomenological and the microscopic points of view. It is not assumed that the gyration radius of electrons is larger than the Debye length. The rate of relaxation between ion and electron temperatures in a fully ionized gas increases with the magnetic field. When the gyration radius r_g of the electrons is shorter than the Debye length l_D the rate of relaxation is proportional to

$$\ln(kTl_D/Ze^2) + \tfrac{1}{2}\,[\ln(l_D/r_g)]^2,$$

where Ze and −e are the charges of an ion and an electron, respectively. The thermodynamics of irreversible processes is applied in general and it is shown that the Onsager—Casimir reciprocity relation takes a symmetrical form for plasmas in a magnetic field. For a two-component fully ionized gas where the electrons make free gyrations interference between electrical and thermal conductions vanishes. In this case the diagonal elements of coefficient tensors for the electric conduction and diffusion perpendicular to the magneti field are proportional to

$$\ln(kTl_D/Ze^2) + \tfrac{3}{4}\,[\ln(l_D/r_g)]^2,$$

when the gyration radius r_g of the electrons is shorter than the Debye length l_D.

5449 TRANSPORT EQUATION OF A PLASMA.

R.Balescu.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 719-20 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). A rigorous equation, derived from the general principles of statistical mechanics of irreversible processes, is discussed. The characteristic divergences which appear in the usual treatments of long range forces (Boltzmann or Fokker—Planck equations) disappear in ne present method. The equation correctly describes the collective nteractions of a large number of particles. This feature introduces new kind of nonlinearity. The physical meaning of the equation is nat it describes the interaction of particles which are dressed by neir polarization clouds. The latter has not a spherical shape as in quilibrium, but is deformed by the motion of the particles and may egenerate (for large velocities) into a wake of plasma oscillations.

5450 DYNAMICAL EQUATIONS AND TRANSPORT RELATIONSHIPS FOR A THERMAL PLASMA.

.Herdan and B.S.Liley.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 731-41 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Jsing Grad's thirteen moment approximation for the velocity distriution functions, a closed set of dynamical equations for a multiomponent gas mixture, in the presence of a magnetic field, have een derived. On the assumption of binary encounters, the associted collision integrals have been performed. The components of the nixture are assumed to be at different temperatures. Explicit xpressions for these integrals are given for the case of an lectron—ion (one type only) mixture. Transport relationships have een deduced from these dynamical equations. These produce, in articular, a modified form of the generalized Ohm's law and introuce additional terms in the accepted expressions for the non-hydrotatic components of the stress tensors.

5451 PLASMA TURBULENCE.

L.S.G.Kovásznay.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 815-22 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Recent experimental evidence obtained in high energy electrical lischarges strongly supports the existence of plasma turbulence. Since most experiments employ large macroscopic electric currents nd have intense magnetic fields the turbulent fluctuations are exected to be very far from an isotropic condition. In such a case the nalytic approach also must be made more along the line of turbulnt shear flows (turbulent pipe flow, axisymmetric jet, etc.) where here are strong preferred directions and the assumption of isoropy becomes useless. For an exploratory study the validity of he simple magnetohydrodynamic equations are assumed and attenion is confined to solenoidal turbulent fluctuations. Using the Reynolds-type of approach equations are obtained for the mean flow nd mean electromagnetic field and also for the turbulent kinetic nergy and turbulent magnetic energy of the fluctuating fields. The oupling between mean quantitaties and fluctuations is due to the onlinearity of the original governing equation. Three main results re obtained from the analyses: (1) The momentum equation for ne mean flow contains extra stress terms contributed by the average ouble velocity products (Reynolds stress). These turbulent stresses nust be balanced by magnetic pressure if turbulent plasmas are to e confined. (2) The average (vector) product of turbulent velocity nd magnetic field fluctuations (double correlation) gives rise to a nacroscopic electric field opposing and d.c. electric current. As result a macroscopic turbulent resistivity of the plasma is obained that is essentially independent of the value obtained from the as conductivity formula and can exceed it even by an order of nagnitude. (3) The turbulent energy equations (both kinetic and nagnetic) indicate how the energy of the mean field is transferred kinetic turbulence and the energy of the kinetic turbulence is ansferred to magnetic turbulence and then finally dissipated by ne gas resistivity and by some other dissipative process.

5452 MOTION OF A COMPLETELY IONIZED GAS ACROSS A MAGNETIC FIELD IN THE PRESENCE OF AN LECTRIC FORCE.

J.M.Burgers.
ev. mod. Phys. (USA), Vol. 32, No. 4, 868-80 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). he equations of motion are considered for a fully ionized gas ithout collisions, including equations for the pressure tensor comonents and for third order moments. They are applied to a superonic flow field depending upon one çoordinate (x) only, stationary time; magnetic force parallel to the z-axis, electric forces along ne x-axis and y-axis (E_2 = constant); flow velocity small compared ith light velocity. The smallness of the mass ratio electrons/ions ermits some simplifications. Solutions are investigated (a) for a ase where third order moments are neglected; (b) for a case where ome of these moments are retained, making a simplifying assumpon concerning fourth order moments. The results indicate the ossibility of oscillations with a wavelength of the order of the ion Larmor radius. In the discussion appended to the paper a comparison is made with results obtained by Hain, Lüst and Schlüter on the same problem, who used a different scale of length.

5453 MAGNETOHYDRODYNAMIC SHOCK WAVE IN A COLLISION-FREE PLASMA.

F.J.Fishman, H.E.Petschek and A.Kantrowitz.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 959-66 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The understanding of the basic dissipative mechanism in high temperature plasmas is basic to the treatment of all flow problems. As a particular example, the dissipative mechanisms occurring in a shock wave, propagating in a plasma with the mean free path for interparticle collisions very large compared to the Larmor radius is considered. It is shown that waves are amplified in such a shock and that the integration of these waves determines the shock thickness. The entropy production required by the shock wave is obtained by collisions of these waves due to their non-linear interactions. The mean free path for these waves is of the order of the ion Larmor radius. This short mean free path implies that continuum magnetohydrodynamics can be applied in many cases even when the interparticle mean free path is quite large. Both the shock thickness and its dependence on the Alfven Mach number obtained in this manner are in agreement with experiment.

5454 THE PLASMA-SHEATH TRANSITION IN A MAGNETIC FIELD.

J.E.Allen and F.Magistrelli.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1138-47 (Dec. 16, 1960).

A criterion for sheath formation is presented which allows for the effect of a weak magnetic field. Relevant measurements were made using a low pressure mercury arc in which an azimuthal or "pinch-type" magnetic field could be applied.

PROPAGATION OF ELECTROMAGNETIC WAVES IN A PLASMA WITH STRONG MAGNETIC FIELD. See Abstr. 5598

5455 A CONTRIBUTION TO THE KINETIC THEORY OF THE REFLECTION OF ELECTROMAGNETIC WAVES FROM A MOVING PLASMA.

V.I.Kurilko.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 70-7 (Jan., 1961). In Russian.

The reflection of electromagnetic waves from a semi-infinite moving uniform anisotropically Maxwellian plasma is considered. The electric field satisfies an integro-differential equation which is solved by the Wiener—Hopf method. A formula for the reflection coefficient is derived and discussed. [English translation in: Soviet Physics—Technical Physics (USA)]. O.Penrose

5456 INVESTIGATION OF ELECTRODELESS DISCHARGE IN A MAGNETIC TRAP WITH A SUPPLEMENTARY AZIMUTHAL MAGNETIC FIELD.

Ya.F.Volkob, V.T.Tolok and K.D.Sinel'nikov.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 255-8 (Feb., 1961). In Russian.

A fast magnetic trap may be used to pre-heat plasma. Supplementary azimuthal magnetic fields contract the radius of the plasma without changing its compression. This is illustrated by photographs of an argon discharge. X-radiation from the discharge was investigated for various relative dispositions of the magnetizing coils. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5457 CALCULATION OF THE ELECTRODYNAMICAL REPULSION OF AN UNDEFORMED PLASMA RING FROM A MAGNETIC "MIRROR".

E.M.Moroz and I.S.Shpigel'.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 78-83 (Jan., 1961). In Russian.

The problem is idealized into the repulsion of a toroidal mass of plasma by a current-carrying metal ring. The equation of motion of the plasma then lends itself to numerical integration. It is found that the velocity of the plasma quickly attains a limiting value. The velocity and consequently the energy vary with the relative inductances of the plasma and the metal ring and with the coefficient of coupling. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5458 STABILITY OF A PLASMA IN THE FIELD OF A MAGNETIC DIPOLE.

B.B.Kadomtsev and V.E.Rokotyan.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 68-70 (July 1, 1960). In Russian.

For abstract, see Abstr. 19676 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 747-9 (Jan.-Feb., 1961)].

5459 THE ENERGY BALANCE AND CONFINEMENT OF A MAGNETIZED PLASMA.
B.Lehnert.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 1012-19 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Both in cosmical physics and in laboratory experiments there exist situations where the effect of neutral particles will be of importance to the dynamics of an ionized gas. Laws expressing the conservation of mass, charge, momentum and energy for a partially ionized gas are discussed. Collisions leading to ionization and charge exchange are included. It is found not to be necessary to derive the energy equation in terms of the joint action of electromagnetic and mechanical changes of state. A number of important cases are considered where the heating of the plasma is provided mainly by collisions between ions and neutral particles and not by coulomb collisions. An application to the theory is given by the behaviour of a rotating plasma. The pressure balance along the magnetic field lines is studied for a configuration earlier discussed by Alfvén in a theory on the origin of the solar system. The results are also applied to the energy balance in discharge experiments.

5460 MAGNETIC CONFINEMENT OF CHARGED PARTICLES.
J.W.Gardner.

Nuovo Cimento (Italy), Vol. 18, No. 6, 1157-73 (Dec. 16, 1960).

The motion of charged particles in a cylindrical magnetic field is analysed by a perturbation-theoretic method in which the cylindrical field is treated as a perturbation of a uniform field, and is found to contain axial drift terms. These terms are evaluated to second order and used to formulate the conditions for a self-confining effect, such as would be required for plasma-containment in a thermonuclear reactor.

5461 ON THE VALIDITY OF TREATING A DENSE PLASMA AS A METAL IN RADIO-FREQUENCY CONTAINMENT OF PLASMAS.
F.B.Knox.

J. Electronics and Control (GB), Vol. 10, No. 1, 1-11 (Jan, 1961).

The TM_{100} mode is solved for a cylindrical resonator with plasma and metal walls, the plasma being treated formally as a dielectric. When the polarization electric field is considered explicitly together with the total electric field, the approach of Boot et al.(Abstr. 5069 of 1958) to plasma containment by radio-frequency fields is found to give results for the time averaged force on a dense plasma which agree with results obtained by treating such a plasma as a metal. Where the electric field terminates in the plasma surface the plasma tends to be dragged out, and where magnetic field is bounded by the surface the plasma tends to be pushed in.

5462 INVESTIGATION OF A TOROIDAL DISCHARGE IN A STRONG MAGNETIC FIELD.
E.P.Gorbunov, G.G.Dolgov-Savel'ev, V.S.Mukhovatov, V.S.Strelkov and N.A.Yavlinskii.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 10, 1152-64 (Oct., 1960). In Russian.

The second version of the apparatus "Tokamak" differs from the first in the absence of organic materials from the vacuum chamber. Rigorous outgassing of the walls by heating to some 500°C before the discharge fundamentally changes the character of the discharge: the conductivity rises, oscillations occur in the warmed plasma and with their advent X-radiation disappears, a second current maximum appears at low voltages. Optical observations show an increased electron temperature. Increasing the magnetic field assists stability. [English translation in: Soviet Physics—Technical Physics (USA), Vol. 5, No. 10, 1089-99 (April, 1961)].

A.E.I.Research Laboratory

5463 INVESTIGATION OF A TOROIDAL DISCHARGE IN A RAPIDLY CHANGING LONGITUDINAL MAGNETIC FIELD.
D.P.Ivanov and D.D.Kirillov.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 793-6 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 309 of 1961. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 820-3 (Jan.-Feb., 1961)].

5464 SUPERFAST PINCH STUDIES.
L.O.Heflinger and S.L.Leonard.

Phys. of Fluids (USA), Vol. 4, No. 4, 406-23 (April, 1961).

An apparatus designed to accelerate protons of a hydrogen plasma to energies of 1 keV or more by means of the radially converging magnetic piston of a longitudinal pinch has been constructed. A capacitor charged to voltages of up to 350 kV is discharged through the plasma, producing currents of up to 75 kA. The ringing frequency is 18 Mc/s, so that the rate of current rise is about 0.8×10^{13} A/sec. Radially converging luminous fronts with maximum velocities in excess of 50 cm/μsec are observed and are interpreted as shock waves driven by a magnetic piston. Magnetic probe measurements and measurements of the electric field at the wall of the discharge tube show that much of the magnetic flux introduced during the first half-cycle is trapped in the hot plasma. The effects of varying such parameters as the total current, the initial pressure of gas, the type of gas, and the frequency of the discharge have been investigated. The experimental results are interpreted in terms of the classical Rosenbluth—Garwin theory of the pinch, which seems to correlate well with the observations.

5465 ENERGY LOSS FROM A TOROIDAL PINCH DISCHARGE
H.J.Karr, E.A.Knapp and J.E.Osher.

Phys. of Fluids (USA), Vol. 4, No. 4, 424-37 (April, 1961).

Most high-temperature plasma devices, and in particular pinch discharges, have energy-loss rates much larger than can be accounted for in terms of hydrogenic bremsstrahlung or quiescent plasma diffusion. This loss was investigated for a toroidal pinch discharge machine with longitudinal stabilizing magnetic field, Perhapsatron S-4. It is found that the major energy dissipation is due to vacuum ultraviolet emission from partially stripped impurity ions. The impurity is predominantly oxygen liberated from the walls of the tube into the discharge after the pinch has been formed. Characteristics of this radiation are discussed, as well as a possible mechanism for the release of the impurity into the discharge. Comparisons between experimental results and theoretical predictions on the rate of radiation loss are given.

5466 EVIDENCE FOR THE CONTAINMENT OF A HOT, DENSE PLASMA IN A THETA PINCH.
T.S.Green.

Phys. Rev. Letters (USA), Vol. 5, No. 7, 297-300 (Oct. 1, 1960).

Framing-camera pictures were taken axially at 0.26 μsec intervals of second-half-cycle discharges in a 21 cm long 5 cm I.D. alumina tube with magnetic fields rising to $\sim 10^2$ kG in 2.5 μsec. With initial deuterium pressures near 75 μ Hg, the plasma contracts and expands with the magnetic field. Measurements of the plasma radius, together with the assumption of no trapped reverse field and no energy loss, suggest containment times of ~10 μsec, and temperatures and densities consistent with a thermonuclear origin of the observed neutron yield. It is suggested, however, that the inferred good containment is due to closed lines of force round the plasma, due to trapped reverse field.

R.S.Pease

5467 EVIDENCE OF CONTAINMENT OF A 3 keV DEUTERIUM PLASMA.
F.H.Coensgen, W.F.Cummins, W.E.Nexsen,Jr.,and A.E.Sherman.

Phys. Rev. Letters (USA), Vol. 5, No. 10, 459-61 (Nov. 15, 1960).

Using apparatus and techniques previously described (Abstr. 11163 of 1959), deuterium plasma was injected through a static field of 600 G into a pulsed field which compressed the plasma some 30 times in 50 μsec. At 70 μsec, conditions in the plasma were estimated to be: mean ion energy, 2.4-3.2 keV; electron temperature, 20-100 eV; number density, $1\text{-}3 \times 10^{13}$ ions cm^{-3}; total volume 1.6-2.4 litres. These conditions are consistent with observed neutron yields of 10^4 neutrons per operation, spread out over ~900 μsec.

R.S.Pease

5468 MAGNETIC COMPRESSION OF PLASMAS.
A.C.Kolb.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 748-57 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The influence of end losses on the heating of a plasma by magnetic compression is discussed in the case where the plasma radius is large compared to the Larmor radii and the conductivity is high. The effect of the end losses is to increase the temperature of the compressed plasma relative to a purely adiabatic compression. Calculations are carried out for two cases, i.e. when the compression time is (a) greater and (b) less than the ion—ion scattering time. For case (b) the confinement time depends on the coil length mirror ratio and temperature and for (a) on the temperature and density. The scattering time is as in the experiments of Post (1958). Experimental results for a deuterium plasma are compared with the theory, and the scaling laws for the confinement time are approximately verified. Phenomena associated with reverse fields in the plasma are discussed in connection with stability and heating.

5469 PINCH BUCKLING.
K.O.Friedrichs.

ev. mod. Phys. (USA), Vol. 32, No. 4, 889-97 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). cylindrical plasma carrying an axial magnetic field (B_Z) and con-ned by a circumferential magnetic field (B_θ), in the surrounding acuum is unstable if the ratio $|B_Z|/|B_\theta|$ lies below a critical alue. Infinitesimal deviations associated with circumferential and xial wave-numbers m and k are then possible. It is shown that quilibrium states with finite deviations exist for supercritical alues of $|B_Z|/|B_\theta|$, relative to each mode (m, k). Their helical uckled" interfaces are analogous to water wave surfaces. These uckled" states are unstable if the deviation is relatively small. here are indications that stable buckled states with large deviations xist for large wavelengths $2\pi/k$, provided the plasma is enclosed a sufficiently near outer conductor.

5470 BOUNDARY OF A PENETRATING PLASMA AND PLASMA FOCUSING.
.D.Gabovich, L.L.Pasechnik and L.I.Romanyuk.

h. tekh. Fiz. (USSR), Vol. 31, No. 1, 87-93 (Jan., 1961). In Russian.

There are many forms of plasma focusing in which the boundary the plasma lies inside or at the edge of an ion source. When owever the boundary lies outside the source, a well-defined plasma urface extending some distance from the source can be obtained nd used to guide a beam of ions. Experiments with this arrange-ent were carried out using an electrostatic immersion lens. The lasma boundaries were found by a probe method under various onditions of field and geometry. Convenient means of controlling e shape and position of the boundaries can thus be deduced. English translation in: Soviet Physics—Technical Physics (USA)].

A.E.I.Research Laboratory

5471 A PULSED METHOD FOR PROBE MEASUREMENTS IN STATIONARY PLASMA WITH HIGH CURRENTS.
.Hayess.

xper. Tech. der Phys. (Germany), Vol. 8, No. 4, 145-54 (1960). German.

Describes the construction and operation of an apparatus which llows probe measurements of the characteristics of a dense plasma. ne or two probes can be employed and operated for very short eriods. Because of the short duration of the perturbation introduced the probes, errors due to impurities or discharge from the probe rminals are greatly reduced.

G.Martelli

5472 A METHOD OF MEASURING THE POTENTIAL DISTRIBUTION IN A CYLINDRICAL R.F. CAVITY ONTAINING PLASMA.
E.D.Dracott.

. Electronics and Control (GB), Vol. 10, No. 1, 25-32 (Jan., 1961).

A proposed method of determining the electric potential dis-ribution in a cylinder containing plasma is described. The method onsists of shooting an ion beam through the plasma and measuring e position, velocity and direction of the beam at the points of entry nd exit. It is shown that by varying the input parameters, the otential of a particular point inside the plasma can be computed. hus the beam can be used to probe all points inside the plasma nd the space potential as a function of position obtained.

5473 WAVELENGTH DEPENDENCE OF THE REFRACTIVE INDEX OF A PLASMA IN THE OPTICAL REGION.
.Ascoli-Bartoli, A.De Angelis and S.Martellucci.

ovo Cimento (Italy), Vol. 18, No. 6, 1116-37 (Dec. 16, 1960).

The experiment described is designed to put in evidence the part ayed by free electrons in the refractivity of noble gas plasmas. e variations in density of the neutral gas and their relation to the gree of ionization are studied. The method of analysis employed that of optical interferometry. The limits of the sensitivity of is method are also discussed. The plasma was excited by a radio-equency field.

5474 MEASUREMENT OF ENERGY LOSSES IN PLASMA BY A BOLOMETRIC METHOD.
.L.Gorelik and E.A.Lobikov.

. tekh. Fiz. (USSR), Vol. 31, No. 1, 125-7 (Jan., 1961). In Russian.

A toroidal discharge in hydrogen took place in approximately 5 μsec and consumed 12 kJ. The energy balance was investigated a simultaneous measurement of the current and of the tempera-re near the wall. Both quantities were transmitted to an oscillo-aph; the temperature was measured by a bismuth—lead resistance ermometer. Evaluation of the results shows that the Joule heat is almost instantaneously transferred to the wall without showing any appreciable tendency to raise the temperature in the interior of the plasma. [English translation in: Soviet Physics—Technical Physics (USA)].

R.Eisenschitz

5475 SOME REMARKS OF ELECTRIC-DISCHARGE SHOCK TUBE DIAGNOSTICS.
D.Bershader.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 780-4 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Electric-discharge shock tubes have attracted interest as an experimental tool for plasma dynamics research. By now, several investigators have performed studies both with the T-tube backstrap configuration and with coaxial arrangements. Significant results have included: (a) demonstrated linearity between discharge current and luminous front velocity in tubes employing conical (funnel) electrode configurations; (b) constancy of front velocity over a length of ten diameters of the funnel type; (c) opposite dependence of velocity on cone angle at low and high pressures, and (d) verification of the Paschen curves for the case of helium and nitrogen. Additional diagnosis is required before one can assess the fuller potentialities of such tubes for general gas dynamics purposes in the high energy range.

5476 LOW-INDUCTANCE CAPACITOR BANKS AND LINEAR PINCHED DISCHARGES.
A.H.Gabriel, V.T.S.Howell, E.Thornton and R.J.Wilson.

J. sci. Instrum. (GB), Vol. 38, No. 4, 136-42 (April, 1961).

Details are given of low-inductance capacitors and capacitor banks with energy storages in the range 1 to 10 kJ capable of giving maximum currents of 1.2 MA and rates of rise of 6×10^{12} A/sec. The working voltage in the work described is 10 kV, but the techniques have been used at higher voltages, up to 40 kV. An outline is given of measurement techniques, used in the study of linear pinched discharges in low-pressure deuterium with these banks.

5477 CONSTRUCTIONAL DATA AND BASIC PARAMETERS OF THE "ALPHA" APPARATUS.
V.A.Glukhikh, E.G.Komar, B.A.Larionov, I.F.Malÿshev, N.A.Monoszon, A.M.Stolov and N.S.Strel'tsov.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1394-1403 (Dec., 1960). In Russian.

A summary of technical details about this equipment, which is used for the study of discharges in plasmas. Particular attention is paid to the magnetic circuit and to the production and supply of the high electrical currents required. The methods of preliminary ionization of the gas, and the vacuum system and chambers are also discussed, and the control system is briefly mentioned. [English translation in: Soviet Physics—Technical Physics (USA)].

J.E.Gore

5478 MEASUREMENT OF THE FLOW OF ENERGY RADIATED BY THE PLASMA IN THE APPARATUS "ALPHA".
V.A.Burtsev, A.M.Stolov and V.V.Shakhov.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1415-21 (Dec., 1960). In Russian.

An artificial black body and an energy flow meter used in the measurements are described. It is found that only a small part of the energy put into the plasma is registered as coming out. It is supposed that much is lost in local arc discharges and oscillations of the magnetic field. There is also an appreciable delay between the start of the discharge and the moment when energy output begins to be registered. [English translation in: Soviet Physics-Technical Physics (USA)].

A.E.I.Research Laboratory

5479 INVESTIGATIONS OF SPECTRA IN THE "ALPHA" APPARATUS. I. THE NATURE OF SPECTRA AND THE TEMPERATURE.
A.N.Zaidel', G.M.Malÿshev, E.Ya.Shreider, A.B.Berezin, B.A.Belyaeva, B.I.Gladushtak, V.V.Skidan and L.V.Sokolova.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1422-32 (Dec., 1960). In Russian.

The spectra of toroidal discharges in the range between 350A and 5000 A were investigated. A table of more pronounced and identified lines is given. Broadening of the lines was measured and the temperature of ions determined. An increase of the ion temperature with an increase of the magnetic field intensity was demonstrated for N IV and O V. On the other hand a decrease of the temperature of the same ions was obtained when the voltage on a capacitor bank was raised from 10 kV up to 15 kV. It was found that the ion temperature depends on the ionic charge: highly ionized ions reached higher temperatures than ions with a lower charge.

This dependence indicates that some other mechanism, apart from collisions between particles, operates in the discharge. It may be that there is some kind of interaction between ions and electromagnetic-field variations in the plasma. [English translation in: Soviet Physics—Technical Physics (USA)]. W.G.Jordan

5480 INVESTIGATIONS OF SPECTRA IN THE "ALPHA" APPARATUS. II. THE DIRECTED MOTION OF IONS.

A.N.Zaidel', G.M.Malŷshev, E.I.Moskalev, E.A.Ptitsŷna, L.V.Sokolova and G.I.Chashchina.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1433-6 (Dec., 1960).
In Russian.

Highly ionized atoms such as N IV, O IV, and O V possess a comparable drift velocity in a toroidal discharge tube. In order to determine the velocity, the wavelength displacement of the spectral lines was measured. The light leaving the centre of the discharge was viewed in a direction tangential to the axis of the discharge. Two successive photographs were taken with the electric and magnetic fields parallel and antiparallel in order to obtain displacement of the line in two opposite directions. The calculated velocities of ions are in the range of 10^5-10^6 cm/sec and tend to increase of increase of the ionic charge. [English translation in: Soviet Physics—Technical Physics (USA)]. W.G.Jordan

5481 INVESTIGATIONS OF SPECTRA IN THE "ALPHA" APPARATUS: III. TIME CHARACTERISTICS OF THE PLASMA EMISSION.

A.N.Zaidel', G.M.Malŷshev, A.B.Berezin and G.T.Razdobarin.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 12, 1437-46 (Dec., 1960).
In Russian.

Variation of the spectral line intensity with time was followed by photographic and photoelectric methods. A method was developed for recording line profile in relation to the pulse phase. Oscillograms of H_β and N IV at 3479 A are presented. They differ considerably from each other depending on the conditions of discharge. A method by which two halves of a spectral line could be recorded independently and simultaneously is described and the resulting oscillograms presented. From the noticeable phase shift of the oscillations, which represent intensity variations of both halves of the line, the authors draw the conclusion that ions taking part in the discharge represent some regular movement. [English translation in: Soviet Physics—Technical Physics (USA)]. W.G.Jordan

Plasma Oscillations

5482 A SIMPLE PLASMA OSCILLATOR.

G.C.McCullagh.
J. sci. Instrum (GB), Vol. 38, No. 4, 164 (April, 1961).

A simple and easily constructed plasma oscillator is described, giving power of the order of microwatts, and tunable over rather wide ranges, e.g. 40-55 cm, by varying the anode voltage.

5483 THE WAVE MOTIONS OF SMALL AMPLITUDE IN A FULLY IONIZED PLASMA WITHOUT EXTERNAL MAGNETIC FIELD.

S.I.Pai.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 882-7 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). These are studied using the two-fluid theory. The motion can be separated into three groups of waves, two transverse to the direction of propagation and one longitudinal. The wave motion arising when no external magnetic field is applied, is analysed in detail. For a plasma with infinite electric conductivity undamped waves can exist. The two transverse wave motions occur only when the frequency ω of the wave is higher than the plasma frequency of the electrons ω_e. As regards undamped longitudinal waves, there is only one mode of wave propagation when (ω/ω_e) is smaller than unity. At low frequencies the speed of propagation of this mode is the ordinary sound speed for the plasma considered as a single fluid. The speed of propagation decreases when the frequency ω of the wave increases, and tends to a limiting value equal to the sound speed of the ion gas of the plasma, moving as if the electrons did not take part in the motion. When ω/ω_e is greater than unity, a second undamped wave appears. The speed of propagation of this second wave is infinite at $\omega/\omega_e = 1$; it decreases toward the limiting value of the sound speed of the electron gas as the frequency increases towards infinity. Various damped types of waves have been found and are discussed for finite electric conductivity.

5484 HYDROMAGNETIC WAVES OF FINITE AMPLITUDE IN A PLASMA WITH ISOTROPIC AND NON-ISOTROPIC PRESSURE PERPENDICULAR TO A MAGNETIC FIELD.

K.Hain, R.Lüst and A.Schlüter.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 967-72 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Hydromagnetic waves of finite amplitude propagating perpendicular to a magnetic field in a plasma with zero pressure have been discussed by Adlam and Allen (Abstr. 3262 of 1958), and by Davis, Lust and Schluter (Abstr. 2522 of 1959). In this investigation similar waves are treated for two different cases. First it is assumed that the gas pressure perpendicular to the magnetic field is isotropic. In this case, the problem can be reduced to a second order differential equation describing, for instance, the variation of the magnetic field in space. This equation is equivalent to the equation for an one-dimensional unharmonic oscillator, and is solved numerically. The essential features of the solutions can be obtained by studying the potential of the waves and wave trains as solutions. The properties of these solutions are discussed. Secondly it is assumed that the gas pressure perpendicular to the magnetic field is non-isotropic. In this case all moments of the collision-free Boltzmann equation up to the second order in the velocity for two different kinds of particles with opposite charge are taken into account neglecting only those terms which correspond to the heat conductivity. It is shown that there exists an invariant involving the determinant of the pressure tensor which corresponds to the adiabatic invariant in the case of isotropic pressure. Special solutions (all quantities shall be constant at $-\infty$) are obtained numerically for different ratios of the masses of the two particles. If the mass-ratio is different from unity, the solutions are similar to a solitary wave but with three maxima, while for equal masses there exists only one maximum. The pressure in these waves becomes highly unisotropic for the heavier particles as well as for the lighter particles. Simple limits with the mass-ratio tending to zero or infinity do not seem to exist.

5485 OSCILLATIONS OF A PLASMA IN A STATIC EXTERNAL MAGNETIC FIELD.

S.Ciulli and M.Micu.
Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 489-96 (1958).
In Roumanian.

Using the Boltzmann equation the distribution function of an ensemble of electrons in a cylindrical plasma placed in an axial magnetic field is determined. C.S.Morgan

5486 EXCITATION OF IONIC CYCLOTRON OSCILLATIONS IN A PLASMA BY ELECTRON BEAMS.

O.A.Glasov, L.V.Dubovoi and B.H.Rutkevich.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 84-6 (Jan., 1961). In Russian.

The high-frequency heating of plasma by means of ionic cyclotron resonance is not too efficient for large volumes and large magnetic fields. But ionic cyclotron oscillations can be induced by modulated electron beams, so arranged that electron bunches spiral round the magnetic field. Calculations show that greatly improved efficiency is attained in this way. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5487 PROPAGATION OF IONIC CYCLOTRON WAVES IN A PLASMA.

N.I.Nazarov, A.E.Ermakov, V.T.Tolok and K.D.Sinel'nikov.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 254-5 (Feb., 1961). In Russian

Under suitable conditions direct measurement of high-frequency signals may be made on the axis of a plasma discharge tube. It is shown that the amplitude of the signals depends on the degree of ionization of the plasma. Experiments reveal the penetration of high-frequency energy into the plasma in the form of cyclotron waves. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I. Research Laboratory

ELECTRON EMISSION
ELECTRON BEAMS

5488
MEASUREMENT OF THE TEMPERATURE VARIATIONS IN THE WORK FUNCTION OF METALS.

Comşa, A.Gelberg, B.Iosifescu and G.Musa.
ıd. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 429-43 (1958).
Roumanian.

Experimental techniques for high precision measurements of rk function by the displacement of the characteristics are given. ıese were used in conjunction with ultra-high vacuum technique -4 × 10^{-9} torr). Measurements over the temperature range of 0°-400°C only occupied one minute. Results on Mo show the riation to be non-linear over the range 300°-900°C, the work nction diminishing by 0.06 V from 860° to 300°C. A.H.W.Beck

A CIRCUIT FOR CURRENT STABILIZATION DURING THE EASUREMENT OF CHANGES IN WORK FUNCTION.
e Abstr. 5403

5489
EFFECT OF TEMPERATURE ON THE EMISSION OF ELECTRONS FROM ABRADED SURFACES OF ERYLLIUM, CALCIUM, ALUMINUM, AND MAGNESIUM.

C.Ku and W.T.Pimbley.
appl. Phys. (USA), Vol. 32, No. 1, 124-5 (Jan., 1961).

Exoelectron emission counts were made for freshly abraded ecimens which had first been stored at -195 or 500°C. The ectron decay curves obtained qualitatively agree with a proposed eory based on the diffusion of vacancies to the surface of the metal.
W.G.Townsend

5490
NOVEL PROPERTIES OF ELECTRON EMISSION SYSTEMS CONTAINING THIN DIELECTRIC LAYERS.

.I.Elinson and A.G.Zhdan.
ıdiotekhnika i Elektronika (USSR), Vol. 4, No. 1, 135-7 (Jan., 1959).
Russian.

The field emission of a W-SiO_2-SiO_2, C surface was investi- ted. It was found that stable emission was obtained at compara- ely low voltages but that at a certain value of emission current eakdown occurred, resulting in a crater. The emission however d not cease. The characteristics of this emission are: it mmences at comparatively high voltages (5-10kV), the current creases with decrease of voltage, decrease in temperature produces increase in current and the emission is stable. Some possible planations of this are put forward. R.C.Glass

5491
PHOTOELECTRIC EMISSION FROM SOLID LAYERS OF ORGANIC DYES. F.I.Vilesov and A.N.Terenin.

ıkl. Akad. Nauk SSSR, Vol. 133, No. 5, 1060-3 (Aug. 11, 1960). In ıssian.

For abstract, see Abstr. 17028 of 1960. [English translation in: viet Physics--Doklady (USA), Vol. 5, No. 4, 840-2 (Jan.-Feb., 61)].

5492
GLIMPSE OF SOME PROBLEMS ENCOUNTERED IN THE STUDY AND CONSTRUCTION OF PHOTO- ULTIPLIERS WITH FAST RESPONSE. G.Pietri.

de (France), Vol. 15, 120-31 (March-April, 1960). In French d English.

A general analysis of some of the problems inherent in the sign of high-gain (~ 10^9), fast-response (~ 10^{-9} sec) photomulti- ier tubes for use with scintillation counters. The phototube is nveniently studied in two electron-optical regions: the region tending from the photocathode to the first dynode, and the region ntaining the remainder of the dynodes. The conditions for timum space and time focusing are discussed, and lead to the option of a concave photocathode and dynodes. C.H.B.Mee

THE [RIVAL] CLAIMS OF SOME IMAGE STORAGE METHODS ASTRONOMICAL MEASURING TECHNIQUES. See Abstr. 5124

SPECIAL STORAGE TUBES FOR USE IN ASTRONOMY.
e Abstr. 5126

SHORT REPORT ON AMERICAN, ENGLISH AND FRENCH ORK ON THE USE OF IMAGE STORAGE TUBES AND IMAGE TENSIFIERS IN ASTRONOMICAL OBSERVATIONS.
e Abstr. 5127

5493
THE THEORY OF SECONDARY ELECTRON EMISSION FROM METALS. I. G.Bimschas.

Z.Phys. (Germany), Vol. 161, No. 2, 190-204 (1961). In German.

The Sommerfield model for metals is used to decide the electron—metal ion interactions giving cascade secondary production and allowing for the Pauli exclusion principle. Estimates of secondary electron yield and energy distribution are made which show the right order of magnitude and form compared with experiment. G.F.J.Garlick

5494
BRILLOUIN FLOW IN RELATIVISTIC BEAMS. D.C.dePackh and P.B.Ulrich.

J. Electronics and Control (GB), Vol. 10, No. 2, 139-46 (Feb., 1961).

A solution in closed form for Brillouin flow under relativistic conditions in a cylindrical geometry is derived in the limit of low beam temperature. Curves and formulae are given relating density, magnetic field, energy and tangential velocity throughout the beam. In particular it is found that the forward velocity is constant to all orders in the radial coordinate, that under ultra-relativistic conditions the beam of maximum perveance has a forward velocity approaching $c/\sqrt{2}$, and that the maximum current is proportional in the ultra-relativistic limit to the square of the energy of the outermost particles.

INTERACTION OF AN ELECTRON BEAM WITH A FULLY IONIZED PLASMA. See Abstr. 5441

5495
A SIEGBAHN—EDVARSON TYPE IRONFREE DOUBLE FOCUSING BETA-RAY SPECTROMETER.

C.De Vries and A.H.Wapstra.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 121-45 (Aug., 1960).

See Abstr. 3155 of 1956. Describes an ironfree double-focusing beta-ray spectrometer with 30 cm radius for precision energy and intensity measurements. It can be used for the focusing of electrons with an energy up to 2.6 MeV. The cooling system limits errors due to temperature effects to about one part in 10^5 in the relative $B\rho$-values of the electrons throughout the whole energy region. The long- and short-term stability of the coil current, delivered by a d.c. generator, is in the order of 1 : 10^5. External magnetic fields are compensated; fluctuations of the most important component of these fields are automatically suppressed to less than 10^{-8} Wb/m². The field shape satisfies the conditions for first-order focusing in the radial direction and second-order focusing in the axial direction to a high degree: $\alpha = -0.500 \pm 0.003$ and $\beta = 0.39 \pm 0.02$. The maximum transmission is about 1%; the smallest linewidth obtained so far is 0.013%.

5496
A UNIVERSAL BETA-SPECTROMETER WITH DOUBLE FOCUSING TO AN ANGLE OF $\pi\sqrt{2}$. P.S.Samoilov.

Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 33-7 (Nov.-Dec.). In Russian.

Without modifying the magnet poles, it is possible to vary the configuration of the magnetic field to secure the double-focusing of widely divergent electron beams to an angle of $\pi\sqrt{2}$. It is also possible to select an optimum field for actual experimental conditions. The field configuration is preserved in a range of intensities necessary for the investigation of electrons with energy from 2 keV to 6 MeV. [English translation in: Instrum. exper. Tech. (USA), No. 6, 892-6 (Nov.-Dec., 1959; publ. Sept., 1960)].

5497
OPTIMUM CONDITIONS FOR DOUBLE FOCUSING BETA RAY SPECTROMETERS. M.Sakai.

Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 61-9 (July, 1960).

Formulae for the optimum source dimensions and solid angle for the double focusing spectrometer, including the sector-type spectrometer, are given as a function resolution. The maximum luminosities derived from these formulae are compared. It is found that the sector-type double focusing spectrometer, of which the field parameters α and β are equal to $\frac{1}{2}$ and $\frac{1}{4}$, respectively, has a configuration with very good focusing properties. It has, in the sense of the generalized Barber's law, such a configuration that the deflection angle is $\frac{2}{3}\pi$ and the distance between the image and the exit boundary of magnetic field is equal to the reference radius. The results are also compared with the ordinary semicircular spectrometer, the Konopinski type semicircular spectrometer and the solenoid lens type spectrometer. These spectrometers have nearly equal maximum luminosity, about ten times smaller than that of any type of double focusing spectrometer.

5498 BETA-RAY BACKSCATTERING FROM COMPOUNDS. V.S.Venkatasubramanian.
Indian Institute of Science Golden Jubilee Research Volume (see Abstr. 2678 of 1961) p. 163-9.

The backscattering factors were determined for a number of chemical compounds, and these are expressed in terms of the values for the constituent elements by an equivalent atomic number

$$\bar{Z} \text{ (for compound } A_mB_n) = \frac{mZ_A^2 + nZ_B^2}{mZ_A + nZ_B}.$$

The maximum energies of the β-radiation backscattered from some compounds were determined by the aluminium absorption method and the results expressed by the formula $\log E_m = A + k. \log \bar{Z}$.

CALCULATOR FOR SOLVING ELECTRON IRRADIATION PROBLEMS. See Abstr. 4996

ION EMISSION . ION BEAMS

5499 SPACE-CHARGE NEUTRALIZATION AND THERMIONIC EMISSION. R.N.Franklin.
J. Electronics and Control (GB), Vol. 9, No. 5, 385-90 (Nov., 1960).

A hot surface emitting charged particles of both signs was placed near a non-emitting collector maintained at a potential relative to the emitter, and the potential in the region between the electrodes investigated. An exact solution of the density distribution of space charge and the field is derived. Though no analytical expression can be given for the potential distribution, its general shape can be found as a function of the ratio of the number of positive ions to electrons. It is shown that the transition from pure electron emission to ion emission proceeds smoothly and no oscillatory solution for the potential exists.

5500 SPACE-CHARGE EFFECTS IN CYLINDRICAL BEAMS WITH UNIFORM ACCELERATION. C.D.Moak.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 19-22 (July, 1960).

The profiles of cylindrical beams of charged particles undergoing uniform acceleration are derived for a large number of beam intensities, configurations and energies, for the case where the emergent beam is parallel. Derivations of the results are presented and their uses are illustrated. Use of the results for certain cases of nonparallel emergence is outlined. Tables of the integral required in the calculations are available as a Harwell report AERE-R. 3255.

5501 STABILITY OF MOTION OF CHARGED PARTICLES IN BIOT—SAVART FIELD. L.Salvadori.
Nuovo Cimento (Italy), Vol. 18, No. 5, 967-81 (Dec. 1, 1960). In Italian.

A complete and rigorous analysis is presented. This situation, which was discussed partially by Caianiello and Gatti (Abstr. 9714 of 1959) because of its possible interest, as a test case, in problems regarding the design of accelerators or the confinement of accelerated plasma ions, is studied here in detail; it is shown, in particular, that the customary approximate methods for the study of stability may easily lead to wrong conclusions.

5502 QUASI-THERMALIZATION OF A PLASMA BEAM. F.Salz and R.G.Meyerand, Jr.
Phys. of Fluids (USA), Vol. 4, No. 4, 438-44 (April, 1961).

A study of the trajectories of charged particles as they pass through a cusped magnetic field shows that a significant fraction of their original axial kinetic energy is transformed into kinetic energy of rotation around the guiding centres of the particles. The energy-exchange mechanism predicted by an idealized model agrees exactly with the analog computer solution of the equations of motion of a particle and agrees generally with the results of an experiment in which a plasma beam was transmitted through a cusped magnetic field.

5503 INVESTIGATION OF THE DISTRIBUTION OF CURRENT DENSITY IN THE CROSS-SECTION OF AN ION BEAM. S.N.Popov.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 217-23 (Feb., 1961). In Russian.

The distribution of current density, found by moving a slit across an ion beam, is nearly Gaussian, becoming less so as the strength of the ion optical system is increased. The strength of the beam follows pulsations in the applied voltage. A visible paraxial glow in the residual gas gives the diameter of the beam proper; the flanks of the density distribution curves consist chiefly of slow ions. [English translation in: Soviet Physics—Technical Physics (USA)].

A.E.I.Research Laboratory

APPARATUS FOR THE MEASUREMENT OF THE ION CURRENT INTENSITY DISTRIBUTION, IN THE REACTION CHAMBER OF A CYCLOTRON. See Abstr. 5513

5504 ION OPTICS OF SECTOR-TYPE MAGNETIC FOCUSING FIELDS. N.Kadota and S.Ishida.
Mem. Fac. Engng Kyoto Univ. (Japan), Vol. 22, Pt 1, 41-67 (Jan., 1960).

The convergence of the ion beam in the sector-type magnetic focusing field of the mass spectrometer is treated geometrically. The real thickness of the ion beam is considered, and the ratio of the radius of deflection to the beam thickness is included as a common parameter in the expression for the final image width. The treatment is composed of three parts: the first order approximation the second order approximation and the complete convergence. In conclusion, a new type of optical system, consisting of a dual arrangement of circular magnetic fields, is proposed and given the name "Collimatron".

PARTICLE ACCELERATORS

5505 THE 2.5 MeV VAN DE GRAAFF GENERATOR OF THE ELECTRICAL ENGINEERING LABORATORY OF THE TECHNOLOGICAL UNIVERSITY AT DELFT.
W.Leijzers Vis and J.H.Makkink.
Ingenieur (Netherlands), Vol. 72, No. 50, O57-O64 (Dec. 9, 1960). In Dutch.

The general principles of Van de Graaff generators are first explained. The column of the Delft generator is built up from 26 potential discs of 950 mm outside diameter and of maximum thickness 32 mm; they are separated by three 70 mm Araldite insulators. The belt, 610 mm wide, runs between four belt-guards a speed of 81 km/hr. The generator is built in a two-part tank of internal diameter 1660 mm and 4335 mm high. The ion source is of Thonemann type, consisting of a Pyrex vessel with a narrowed portion in which is situated an h.f. coil activated by a 20 Mc/s oscillator. The ion source can be used as a source of either protons or deuterons. The accelerating tube contains 25 porcelain rings and is made high-vacuum tight. Operation and measurements on the ion source and the stabilization of the generator voltage are discussed. A rotating voltmeter used for overall voltage measurements is described.

G.N.J.Beck

5506 THE UTRECHT 850 kV CASCADE GENERATOR. I. BEAM DEFLECTION AND ENERGY CONTROL.
C.M.Braams and P.B.Smith.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 27-39 (July, 1960).

The uniform-field magnet has entrance and exit slits located outside the magnetic field. Since the cascade generator produces a vertical beam, the most convenient choice for the angle of deflectio was 90°. The radius of curvature of the beam in the region of the uniform field is 20 cm, which makes it possible to deflect a 1 MeV beam of He^+ or D_2^+ ions with a field of 14.5 kG. The whole assemb of the magnet and slits can be rotated about the incoming beam in order to direct the beam to different experimental arrangements. Energy control is achieved in two steps: first the exciting current of the magnet is stabilized, the magnetic field being measured with a proton magnetic resonance fluxmeter, and second the high tension is controlled so as to maintain the deflected beam centred on the exit slit of the magnet. The expected energy resolution of the syste has been verified down to an energy spread (full width at half maximum) of 0.15% in proton energy. At this resolution, a useful beam (≅2 μA) is obtainable with a high-frequency ion source delivering a total beam of about 40 μA protons.

5507 THE UTRECHT 850 kV CASCADE GENERATOR. II. THE BEAM INTEGRATOR AND GALVANOMETER.
P.J.M.Smulders and P.B.Smith.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 40-5 (July, 1960).

A current integrator is described for the integration of current om 0.01 to 500 μA with an accuracy of 0.1%. The principle used essentially the same as that of the circuit described earlier by lmer and Hemmendinger [Abstr. 3479B of 1958, Rev. sci. Instrum., l. 28, No. 8, 649-51 (Aug., 1957)]. The modifications effected sult in a considerable reduction in expense, as well as a lower out impedance. Due to increased high-frequency gain, much smaller ndensers are necessary in order to maintain the input voltage thin some hundredths of a volt of ground, at all times. The inte- ated current is measured as the number of output pulses, each lse representing a fixed amount of charge. Except for the conden- rs, no special components are used. A low-impedance electronic lvanometer for operation in series with this integrator is also scribed. This circuit combines the advantages of imperceptible ro drift, fixed calibration, and essentially absolute protection ainst burn-out.

5508 A STABILIZING SYSTEM FOR A 700 kV CASCADE GENERATOR. J.C.Tiemeyer.

clear Instrum. and Methods (Internat.), Vol. 81, No. 1, 117-20 ly, 1960).

A 700 kV 4-stage cascade generator in open air, driving an ion celerating tube with a beam current of 1.2 mA, was stabilized by louble-loop feedback system. A stability of the high voltage of)3% per hour with a maximum deviation of 0.1% was noted on the easuring potentiometer. The energy resolution was found to be proximately 100 eV by measuring (p, γ) resonances in Al^{27}.

5509 TANDEM ELECTROSTATIC ACCELERATORS.

R.J.Van de Graaff.

clear Instrum. and Methods (Internat.), Vol. 8, No. 2, 195-202 ug., 1960).

In this type of accelerator a constant potential is applied to the celeration of the ion beam; however, instead of the conventional ngle voltage application, a number of applications is made in ccession by means of a tandem arrangement of high voltage tubes. is number of voltage applications, which is the number of the -called "stages" of a tandem accelerator, may be two, three, or ur, depending on the design chosen. The principles of this type accelerator are described, and a brief account is given of the sign and performance tests of a two-stage accelerator for an tput rating of 10 MeV and 0.5 μA of protons. Some possibilities r future development are discussed for reaching greater energies means of three and four-stage tandem arrangements. Prelimi- ry experimental results show the feasibility of operating these means of the injection of a beam of neutral particles, thus taining the use of an external ion source at ground potential, as the present two-stage tandem accelerators.

5510 FIELDS EXCITED BY BEAM CURRENTS IN CIRCULAR ACCELERATORS. J.Van Bladel.

clear Instrum. and Methods (Internat.), Vol. 8, No. 1, 1-10 (July, 60).

Formulae are given for the electric and magnetic fields in a cular accelerator of arbitrary cross-section, excited by a non- alloping beam of particles. Both steady-state and step-function nsients are considered.

5511 MEASUREMENT OF MAGNETIC FIELD DISTORTIONS IN ACCELERATORS WITH HARD FOCUSING.

.M.Goryachev, S.V.Skachkov and T.G.Smolyankina.

ibory i Tekh. Eksper. (USSR), 1959, No. 6, 13-17 (Nov.-Dec.) In ssian.

A device is described which permits a quick determination of radial distribution of the magnetic field. The error in measur- g the relative distortion at the moment of injection is $\sim 10^{-3}$, and it creases toward the end of the working cycle, when it can be as tle as 5×10^{-4}. An experimental verification of the correcting ndings, which create surface currents on poles, is described. nglish translation in: Instrum. exper. Tech. (USA), No. 6, 872-6 ov.-Dec., 1959; publ. Sept., 1960)].

5512 A [SCREENED] PROBE FOR MEASURING SMALL CURRENTS IN A CYCLOTRON.

3.Mironov, L.M.Nemenov, N.I.Sokolov and N.N.Khaldin.

ibory i Tekh. Eksper. (USSR), 1959, No. 6, 116-17 (Nov.-Dec.). In ssian.

The probe measures the small currents of multiply-charged s against the background of larger currents due to ions acceler- d by "subharmonics". [English translation in: Instrum. exper. ch. (USA), No. 6, 974-5 (Nov.-Dec., 1959; publ. Sept., 1960)].

5513 APPARATUS FOR THE MEASUREMENT OF THE ION CURRENT INTENSITY DISTRIBUTION, IN THE REACTION CHAMBER OF A CYCLOTRON.

A.Grigoriu, M.Macovei, C.Popescu and T.Toth.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 473-80 (1959). In Roumanian.

Describes a transversal scanning device for the exploration of the beam current distribution across a target. The arrangement has the advantage of simplicity and that it can be used at high beam intensities. S.J.St-Lorant

5514 ENERGY DEGRADING—FOCUSING OF CYCLOTRON BEAM.

W.J.Ramler, J.L.Yntema and M.Oselka.

Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 217-20 (Aug., 1960).

The 60 in. cyclotron of the Argonne National Laboratory is a fixed 10.8 MeV/nucleon accelerator. To increase machine flexibility, it was desired to obtain variable energy projectiles 25-40 ft from the accelerator without severely reducing particle number and beam definition. Sacrificing energy resolution, a focused variable energy beam can be obtained by using the technique of a foil absorption system close-coupled with strong focusing provided by quadrupole magnets. The system described can readily degrade a deuteron or alpha beam to about 2.5 MeV/nucleon with about 5% of the original particles focused a distance of 35 ft from the accelerator.

5515 A SYSTEM OF EXTREMAL REGULATION OF THE INTENSITY OF γ-RADIATION OF A SYNCHROTRON.

A.P.Komar, G.F.Mikheev and N.N.Chernov.

Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 109-15 (Jan., 1961). In Russian.

By adjustment of two inlet parameters — the time of injection and the time of switching on the high-frequency voltage on the synchrotron resonator — extremal regulation of the γ-ray intensity is obtained. A practical scheme is described together with working details. The use of the system is found to increase considerably the stability of the synchrotron, and also simplifies the conditions for obtaining maximum γ-ray intensity. [English translation in: Soviet Physics—Technical Physics (USA)]. J.E.Gore

5516 PROCEDURE FOR MAKING INTENSE SOURCES IN AN ELECTRON SYNCHROTRON.

A.J.Bureau and C.L.Hammer.

Rev. sci. Instrum. (USA), Vol. 32, No. 1, 93-4 (Jan., 1961).

The half-integral resonance method (Abstr. 8004-5 of 1955) is used to increase the amplitude of betatron oscillations. This avoids the difficulty of the beam hitting the injector. Uniform radiation of approximately 1/5 in. radial extent has been achieved on a target. J.W.Sturgess

5517 AN EXPERIMENTAL INVESTIGATION OF THE COMPRESSION OF AN ELECTRON BUNCH IN A 280 MeV SYNCHROTRON.

A.G.Ershov, F.A.Korolev, O.F.Kulikov and B.I.Shkurskii.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 554-7 (July 21, 1960). In Russian.

The method is based on ultrarapid photography of the bremsstrahlung from the bunch through a suitable channel in the vacuum chamber of the synchrotron. The results show that the radial dimensions of the bunch decrease faster than one would expect from an adiabatic law. The vertical dimensions of the bunch decrease according to theory. [English translation in: Soviet-Physics—Doklady (USA)]. G.Martelli

5518 EXPERIMENTAL INVESTIGATION OF A NEUTRAL BEAM FROM THE CERN 25 GeV PROTON SYNCHROTRON.

M.Fidecaro, G.Gatti, G.Giacomelli, W.A.Love, W.C.Middelkoop and T.Yamagata.

Nuovo Cimento (Italy), Vol. 19, No. 2, 382-92 (Jan. 16, 1961).

The spectra of photons from the CERN 25 GeV proton synchrotron using aluminium and beryllium internal targets were measured at laboratory angles of 3.2° and 15.9° by means of a lead-glass total absorption Cherenkov counter. While at 3.2° the intensity is slightly higher than that predicted by the statistical model with the assumption of isotropy in the c.m.s., at 15.9° it is about an order of magnitude below this prediction. This is interpreted as an indication of anisotropy in c.m.s. The 3.2° beam, at 64 m from the target, has an intensity of about 13 600 photons above 1 GeV per cm^2 when 10^{11} protons impinge on a beryllium target. The number of neutrons was found to be about a factor of 2 below the number of γ-rays of energy larger than 2 GeV. Attenuation measurements of γ-rays and neutrons were performed in carbon, CH_2 and lead.

5519 APPLICATION OF NUCLEAR RESONANCE IN MAGNETIC MEASUREMENTS IN A PROTON SYNCHROTRON. S.S.Kurochkin and M.P.Zel'dovich.
Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 50-3 (Jan.-Feb.).
In Russian.

A description is given of the application of nuclear magnetic resonance in an experimental 180 MeV proton synchrotron for studying the stability of various field pick-up units, for absolute calibration of these units, for studying the stability of the magnetic field at various points of the magnet, for measuring the induced magnetic field and frequency of the accelerating voltage, etc. A description is given of the apparatus. [English translation in: Instrum. exper. Tech. (USA), No. 1, 54-7 (Jan.-Feb., 1958 publ. April, 1959)].

5520 VIEWING PROBE FOR HIGH VOLTAGE PULSES. W.LeCroy and J.Rosen.
Rev. sci. Instrum. (USA), Vol. 31, No. 12, 1354 (Dec., 1960).

For viewing 50 kV, 0.1 μsec beam deflection pulses on the Nevis synchrocyclotron. Attenuation is produced in two stages, a 25 : 1 coaxial capacitative divider followed by a 100 : 1 resistive divider. J.W.Sturgess

5521 THE BEHAVIOUR OF AN ELECTRON BEAM IN A BETATRON DURING THE INJECTION PERIOD.
Yu.N.Lobanov and N.I.Tulinova.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 194-9 (Feb., 1961). In Russian.

Electron behaviour during injection is conditioned by the mutual interactions of the electrons. Quantitative calculation of this is impeded by a lack of knowledge as to their positions. A useful approximate model consists of a number of regularly interwoven discrete tracks. The validity of this is investigated by placing injectors and probes at regular intervals all round the betatron and observing the way in which the position of one probe affects the current collected by the others. It is found that in fact electrons are not distributed chaotically when injection begins but form a regular series of beams. The distribution of space charge at any point in a radial cross-section of the betatron is, however, broadly Gaussian. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I.Research Laboratory

5522 FREE MOTION OF PARTICLES IN ACCELERATORS WITH CONSTANT FIELD AND STRONG FOCUSING.
A.P.Fateev.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 238-53 (Feb., 1961). In Russian.

Present interest in the collision of beams in accelerators of the phasotron type requires a knowledge of the motion of free particles in these. General relativistic equations of motion for particle orbits in accelerators with constant magnetic field and strong focusing are therefore particularised for the case of the phasotron. Expressions for betatron oscillations in the spiral-sector and radial-sector phasotrons are developed. These enable the designer to choose optimum parameters of the magnetic system. [English translation in: Soviet Physics—Technical Physics (USA)]. A.E.I. Research Laboratory

5523 A SIMPLE MEASURING PROCEDURE FOR DETERMINING THE ENERGY LIMITS OF BREMSSTRAHLUNG IN THE PRESENCE OF STRONG ELECTROMAGNETIC DISTURBING FIELDS. A.Eckardt and E.Burger.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 5, 210-16 (1960).
In German.

Describes a manual method of determining the pulse height distribution of bremsstrahlung from a 2.5 kc/s betatron in which the disturbing magnetic field is very great. The unwanted pulses are ignored by the operator who marks the position of the wanted pulses on the screen of a cathode-ray tube. The method was used in checking the performance of a 5 MeV betatron. A.E.I. Research Laboratory

5524 BREMSSTRAHLUNG SPECTRUM OF THE 1000 MeV ELECTRONSYNCHROTRON AT FRASCATI.
G.Diambrini, A.S.Figuera, B.Rispoli and A.Serra.
Nuovo Cimento (Italy), Vol. 19, No. 2, 250-64 (Jan. 16, 1961).

Final results of some measurements on angular distribution on bremsstrahlung of the γ-ray beam of the Frascati electron-synchrotron are given. The experimental results of angular distribution for thick targets fit Schiff's theoretical angular distribution. However a difference between theory and experiments for thin targets is found and this can be explained by multiple crossing through the target by the accelerated electrons. For the spectrum shape, comparing the experimental results with Bethe and Heitler' theory, for thin targets it was found that the experimental points were in fair agreement with the theoretical predictions, while for thick targets a difference in the high-energy range was found.

KILOVOLT, KILOAMPERE SWITCH FOR MEGATRON ACCELERATOR. See Abstr. 5402

MAGNETISM

(The magnetic properties of solids are included under Solid-State Physics; similarly for Liquid State and Gaseous State)

RELATIVITY OF MOVING CIRCUITS AND MAGNETS. See Abstr. 5189

5525 ROTATING COIL MAGNETOMETER FOR THE MEASUREMENT OF THE EARTH'S MAGNETIC FIELD. D.S.Ainslie.
Amer. J. Phys., Vol. 29, No. 5, 333-4 (May, 1961).

5526 MAGNETIC MEASUREMENTS USING PERMALLOY PICKUPS AT A PROTON SYNCHROTRON.
S.S.Kurochkin.
Pribory i Tekh Eksper. (USSR), 1958, No. 1, 53-5 (Jan.-Feb.).
In Russian.

A method is considered for determining the position and shap of the median magnetic surface for the radial field component in the magnet of a proton synchrotron. A description is given of the pickups used for measuring the stability of the fringing field and the field in the magnet gap. Technical data on the fabrication of th pickups are presented. [English translation in: Instrum. exper. Tech. (USA), No. 1, 58-60 (Jan.-Feb., 1958; publ. April, 1959)].

5527 A TEMPERATURE COMPENSATED MAGNETIZING COIL. J.E.Knowles.
J. sci. Instrum. (GB), Vol. 38, No. 4, 160 (April, 1961).

Describes the use of two coils wound with wires of differing temperature coefficients of resistance, the coils being connected in parallel so that their fields oppose each other.

5528 MAGNETIC POLARIZABILITY OF A SHORT RIGHT CIRCULAR CONDUCTING CYLINDER. T.T.Taylor.
J. Res. Nat. Bur. Stand. (USA), Vol. 64B, No. 4, 199-210 (Oct.-Dec 1960).

The magnetic polarizability tensor of a short right circular conducting cylinder is calculated in the principal axes system with a uniform quasi-static but nonpenetrating applied field. One of the two distinct tensor components is derived from results already obtained in connection with the electric polarizability of short conducting cylinders. The other is calculated to an accuracy of four to five significant figures for cylinders with radius to half-length ratios of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, and 4. These results, when combined with the corresponding results for the electric polarizability, are applicab to the problem of calculating scattering from cylinders and to the design of artificial dispersive media.

5529 FIELDS EXTERNAL TO OPEN-STRUCTURE MAGNETIC DEVICES REPRESENTED BY ELLIPSOID OR SPHEROID. H.Chang.
Brit. J. appl. Phys. Vol. 12, No. 4, 160-3 (April, 1961).

The mathematical expressions for the field intensities externa to spheroids or an ellipsoid with uniform magnetization are given. They are useful in predicting fields external to (a) open-structure magnetic devices such as metallic or ferrite films, twistors or splinters, and (b) spheroidal and ellipsoidal samples which are oft used in magnetic measurements. Curves are plotted to indicate th spatial variation of field intensity with the dimensional ratio of a spheroid as a parameter. In the region near the spheroid, field

ensity is normalized against field intensity at the boundary. In
region far from the spheroid, field intensity is normalized
iinst that of a dipole of the same dipole strength as the spheroid.

5530 POSSIBILITIES OF ALL-MAGNETIC LOGIC.
U.F.Gianola.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 27S-34S (March, 1961).

A sequential logic circuit must have a capacity for memory,
directionality, and gain. The problem of obtaining these features
magnetic components is considered, and a number of approaches
e described. The organization of a circuit using multiapertured
res is discussed, and a method for introducing added combina-
nal logic in a compatible manner is described. The status of
ese techniques is summarized.

5531 MAGNETIC CORE LOSSES RESULTING FROM A ROTATING FLUX. A.Kaplan.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 370S-373S (March,
61).

Most work in the past for determining magnetic core losses has
en based on the assumption of an alternating flux. However, in
rts of many machines such as generators, the flux rotates rather
in alternates. Because of this, it would be advantageous when
lculating the losses in a machine if data on losses due to a
tating flux were available. At the 1957 Conference on Magnetism,
paper was delivered in which the magnetic core loss comparator
so known as the magnetic probe) was described. Since that time,
procedure has been devised by means of which the magnetic core
sses caused by a rotating flux can be determined using this instru-
nt. One obtains a rotating flux by inserting the legs of a cross-
aped lamination into two sets of magnetizing coils, each set at
ht angles to the other. If the phases of the magnetizing currents
ng into each set of coils are adjusted so that the resulting fluxes
e 90° out of phase (electrically) with one another, a rotating flux
sults in the lamination. Core loss readings are made every 30°
ometrically) about a point near the center of the lamination using
magnetic probe. The actual loss of the material can then be
ermined by adding the losses in any two mutually perpendicular
ections. Core loss measurements were made under varying flux
ditions ranging from a pure alternating flux (flux in only one
ection) to a pure rotating flux (flux in two mutually perpendicular
ections of equal magnitude). Intermediate to these two extremes,
asurements were made with the flux densities in the two direc-
ns of unequal magnitude. This latter condition is a close approxi-
tion to that found in an actual generator. Utilizing the above
hnique, the magnetic core losses caused by a rotating and an
ernating flux were determined for an oriented and a nonoriented
icon iron. With both materials, the rotating losses were sub-
ntially higher than the alternating losses with the relative increase
ng greater for the oriented iron. However, the oriented iron was
ll the lower loss material under all flux conditions.

ELECTROMAGNETISM MAGNETOHYDRODYNAMICS

5532 FREQUENCY DEPENDENCE OF INDUCED CURRENTS. P.Graneau.
it. J. appl. Phys. Vol. 12, No. 4, 146 (April, 1961).

"Non-Destructive Testing" Conference, London, May, 1960
e Abstr. 5132 of 1961). Attempts to solve Maxwell's equations
regions inside electrical conductors generally meet with insuper-
e mathematical obstacles, unless a uniform magnetic field can be
umed to exist. In many practical instances the field will be non-
form, since it is generated by currents flowing along wires. The
k of formulae for realistic geometrical arrangements is keenly
in two cases. They are the prediction of eddy-current power
ses and the development of electromagnetic methods for non-
tructive testing. A metallic body can be considered to consist of
infinite number of closed filamentary circuits, coinciding with
streamlines of induced currents. It is then shown, for the most
eral case, how to express the current at any point in the metal
an infinite series of increasing powers of the frequency of a
usoidal current flowing in an energizing filament. The coef-
ents of the series are functions of conductor geometry, elec-
al conductivity and magnetic permeability, but not of the current
itself. This opens the way to measurements on scale models, the long numerical calculation of coefficients by digital computers and the tabulation of normalized coefficients for geometrically similar systems. Some possible causes of the "anomalous eddy-current loss" in magnetic laminations are briefly reviewed in order to illustrate the differing opinions that are still being held on this subject. It would, therefore, seem advisable to re-examine the methods of measuring eddy-current losses with reference to the theory of coupled circuits, and thereby determine whether the classical formulae are sufficiently good approximations. Experiments for this purpose are discussed.

5533 THE MAGNETIC FIELD DUE TO A SKEW PAIR OF LINEAR CURRENTS. S.S.Ștefânescu.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 387-99 (1959).
In Roumanian.

Calculations are presented showing that the lines of force, due to a pair of oppositely directed currents flowing along paths which lie along two neighbouring generators of a hyperbolic paraboloid, follow open helical curves. E.F.W.Seymour

5534 ELECTROMAGNETIC RADIATION FROM A FREELY GRAVITATING CHARGE. A.Peres.
Ann. Phys. (USA), Vol. 12, No. 1, 86-90 (Jan., 1961).

It is shown that a charge, accelerated by a gravitational field, radiates as if it were accelerated by any other external force. General relativistic effects appear only as corrections, which can be neglected for slow motions in weak fields. The bearing of this fact upon the equivalence principle is discussed in relation to the work of DeWitt and Brehme (Abstr. 8538 of 1960).

5535 MOTION OF A CHARGED PARTICLE IN A SLOWLY VARYING MAGNETIC FIELD. L.J.F.Broer.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 742-3 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). In a homogeneous field varying in time the magnetic moment of the particle is constant in first approximation. Expressions for the variation of the moment and for the shift of the centre of motion in higher approximations are derived. An analogy with approximate solutions of the wave equation is pointed out.

5536 MAGNETIC SURFACE EFFECT DUE TO THE ACTION OF A PULSATING TWO-COMPONENT FIELD ON THE SURFACE OF A SEMI-INFINITE SPACE. Yu.D.Sȳchev.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 412-19 (1958).
In Russian.

Expressions are obtained for the induction, current density and active power in a conducting semi-infinite space due to the presence on its surface of a pulsating, 2-component magnetic field. It is shown that the present results can be applied to the analysis of induction heating apparatus. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 34-42 (1958)].

5537 VORTICITY AND CIRCULATION IN A COMPRESSIBLE VISCOUS FLOW IN THE PRESENCE OF MAGNETIC FIELD. P.L.Bhatnagar.
Indian Institute of Science Golden Jubilee Research Volume (see Abstr. 2678 of 1961) p. 194-200.

General equations are derived and a study is made of the special cases in which vorticity and circulation are preserved.

5538 THE FLOW OF A CONDUCTING, VISCOUS LIQUID BETWEEN TWO POROUS PLATES.
N.P.Dzhorbenadze and D.V.Sharikadze.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 299-302 (July 11, 1960). In Russian.

For abstract, see Abstr. 19899 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 673-6 (Jan.-Feb., 1961)].

5539 THE MAGNETOHYDRODYNAMIC PROBLEM OF FLOW ROUND SOURCES OF MAGNETIC FIELD BY A STREAM OF IDEAL PERFECTLY CONDUCTING FLUID.
G.A.Grinberg.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 23-8 (Jan., 1961). In Russian.

Two-dimensional flow is treated, the sources being line currents perpendicular to the planes of flow. The magnetic field is confined to cavities surrounding the sources. It is difficult to find the shapes of these cavities exactly for given source distributions of field and flow; it is proposed instead to assume a given cavity shape and current distribution, and to calculate the flow consistent with it.

The method is exemplified by applying it to a problem originally treated by Cole and Huth (Abstr. 1198 of 1960). [English translation in: Soviet Physics—Technical Physics (USA)]. O.Penrose

5540 SOME "PROGRESSIVE" [SELF-SIMILAR] PLANE-WAVE MOTIONS OF A GAS IN MAGNETOHYDRODYNAMICS.

O.A.Berezin.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 296-8 (July 11, 1960). In Russian.

For abstract, see Abstr. 15119 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 670-2 (Jan.-Feb., 1961)].

5541 FLOW OF A CONDUCTING GAS ROUND A CURRENT-CARRYING PLATE.

A.P.Kazantsev.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 318-20 (July 11, 1960). In Russian.

For abstract, see Abstr. 15124 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 771-3 (Jan.-Feb., 1961)].

5542 ON THE INTERACTION OF STRONG SHOCK WAVES WITH AN ELECTROMAGNETIC FIELD.

V.P.Korobeinikov and V.P.Karlikov.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 764-7 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 19911 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 679-83 (Jan.-Feb., 1961)].

5543 THE STABILITY OF AN INFINITE GRAVITATING CYLINDER OF PARAMAGNETIC MATERIAL IN THE PRESENCE OF MAGNETIC FIELD.

N.K.Nayyar and G.S.Murty.

Proc. Phys. Soc. (GB), Vol. 76, Pt 5, 800-2 (Nov., 1960).

A previous investigation of the influence of longitudinal electric field on the stability of a dielectric liquid cylinder is extended to the case of a paramagnetic liquid cylinder in the presence of a longitudinal magnetic field. The results obtained by Chandrasekhar and Fermi (1953), Auluck and Kothari (1957) and Simon (1958) follow as limiting cases. M.Hasan

5544 CONVECTIVE INSTABILITY INDUCED BY GRAVITY IN A PLASMA WITH A FROZEN-IN MAGNETIC FIELD.

W.A.Newcomb.

Phys. of Fluids (USA), Vol. 4, No. 4, 391-6 (April, 1961).

The convective instability induced by gravity in a compressible fluid layer is investigated in the special case of a plasma with a frozen-in magnetic field B. The necessary and sufficient condition for stability, which is here derived from the hydromagnetic energy principle, is that the density gradient should exceed a certain critical value that is independent of B. Thus the rigidity given to the plasma by the frozen-in field does not suffice to remove the instability but only to slow it down. The growth rates of the unstable displacements are calculated by means of a normal mode analysis and are shown to be inversely proportional to B when B is sufficiently large.

5545 PROBLEMS IN MAGNETO-FLUID DYNAMICS.

L.Spitzer, Jr.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 696-700 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The present status of knowledge is briefly reviewed and important unsolved problems are pointed out. The following research areas are distinguished, according to the restrictions on the macroscopic plasma velocity: zero velocity, including analyses of plasma equilibria; infinitesimal velocity, including, on the one hand, the theory of wave propagation in uniform and non-uniform media, and, on the other hand, instabilities of both hydromagnetic and electrostatic types; finite but steady velocity, including flow of gas around airfoils, and steady, finite amplitude waves; finite unsteady velocity, inlcuding collisionless shocks and turbulence. The most important unsolved problems of magneto-fluid dynamics are largely in this last category of fluctuating finite disturbances.

5546 SOME REMARKS ABOUT FLOW PAST BODIES.

W.R.Sears.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 701-5 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). An attempt to draw some general conclusions about steady flows past solid bodies in the presence of external magnetic fields. At small magnetic Reynolds numbers R_m such flows exhibit wake-like regions of vorticity and current flow whose orientations are determined by the relative strength of the stream velocity and magnetic field. There are analogies between these flows and conventional viscous flows at small Reynolds numbers. At large values of R_m th wake-like disturbances are replaced by standing wave-like disturbances, whose tendency to diffuse at distances from the body is less the larger in R_m. In the limit $R_m \to \infty$, for slender bodies, these are standing acoustimagneto-hydrodynamic waves whose orientation ca be predicted by means of the characteristic wave-propagation diag ("Friedrichs diagram"). This diagram predicts that bodies will be accompanied by four or two families of waves in various cases. Th case of "aligned fields" is a degenerate one in which two families o waves coincide with streamlines and (for finite R_m) form wakes extending either up- or down-stream. Thus aligned-field flows for certain speeds exhibit no waves. Actual observation of these phenomena in experiments has yet to be achieved.

5547 HYDROMAGNETIC EQUILIBRIUM EXPERIMENTS WIT LIQUID AND SOLID SODIUM.

S.A.Colgate, H.P.Furth and F.O.Halliday.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 744-7 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr.   of 1961). Equilibrium surfaces between a rapidly oscillating magnetic field and a "diamagnetic" fluid (liquid sodium) can be recorded by freezing the sodium after the desired equilibrium surface is achieved. A casting can then be made for accurate analysis. In th simple case where an H_Θ magnetic field surrounds a vertical cylin rical rod, the shape and stability of the equilibrium surface betwee the field and the surrounding liquid sodium can be predicted theore ically and have been checked experimentally. The effective specifi gravity of the liquid sodium is controlled by immersing the sodium in an oil of similar mass density. More general configurations, bo mirror and cusp, for which stability and surface configuration are not analytically obvious, are being performed.

5548 SOME STUDIES OF FREE-SURFACE MERCURY MAGNETOHYDRODYNAMICS.

R.A.Alpher, H.Hurwitz, Jr, R.H.Johnson and D.R.White.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 748-69 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Theoretical and experimental studies are reported of shallow free-surface mercury flows transverse to a magnetic field. When stead channel or rotational flows characterized by large Hartmann numbers are contained by insulators, there is induced an electric field such that the "velocity" of the lines of force, $c\vec{E} \times \vec{B}/B^2$, equals th fluid velocity $\vec{\mu}$. Damping arises from viscosity and Joule heating the extremely thin high-current-density Hartmann boundary layer. When the return paths for flow-induced currents lie in a conducting container or region, the $\vec{\mu} = c\vec{E} \times \vec{B}/B^2$ condition does not hold, an flow phenomena are conditioned by the fact that the pressure gradient per unit flow must be larger by a factor equal to the Hartmann number than in the case of wholly flow-confined currents. It is fou that shallow mercury flows may be used for a magneto-hydraulic analogy. Irrotational surface waves, basic to this analogy, are discussed and shown to have a characteristic damping time which is entirely the result of Joule losses, and which is equal to the Hartmann number times the characteristic damping time for rotational flows.

5549 EXPERIMENTS ON THE PASSAGE OF A SHOCK WAV THROUGH A MAGNETIC FIELD.

K.Dolder and R.Hid

Rev. mod. Phys. (USA), Vol. 32, No. 4, 770-9 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). A combustion driven shock tube, 3.4 cm bore, was used to generat a rapidly moving stream of partially ionized argon through a short circular coil producing a magnetic field, the strength B of which a the coil centre being up to 3 $\mathrm{Wb\,m^{-2}}$ (3×10^4 Oe). The range of conditions studied corresponds to shock Mach numbers up to nearl 20 and initial gas pressures 0.05 to 6 cm Hg. Strong hydromagnet interaction occurred when the appropriate Lundquist number $Lu = BL\sigma\,(\mu/\rho)^{1/2}$ exceeded about 0.4, the highest value of Lu attained being about 2, where σ is the electrical conductivity of th gas, μ denotes magnetic permeability, taken as equal to that of fre space, ρ is the gas density and L is a typical length, taken here a 1 cm. The corresponding magnetic Reynolds number Rm was usua about 0.5. Below a certain initial gas pressure, no interaction was observed. This has been interpreted as a result of ionization rela tion, which, at low pressures, leads to a much lower conductivity than equilibrium theory predicts. The distortion of the luminous front as it emerges from the region of the coil has been studied. This front, which is curved, undergoes oscillations in shape, and is ollowed by a number of alternate light and dark bands. The lumin- sity pattern further upstream of the shock front resembles the flow attern in a supersonic jet passing through a constriction. Deter- ninations of the electrical conductivity based on measurements of e induced electric currents agree fairly well with the results of ther workers.

5550 ON TURBULENT MAGNETO-FLUID DYNAMIC BOUNDARY LAYERS.

L.G.Napolitano.

ev. mod. Phys. (USA), Vol. 32, No. 4, 785-95 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The mechanisms of the mean and turbulent kinetic energy trans- er within the boundary layers of electrically conducting fluids are ormulated and discussed in the case when there is no direct trans- er between turbulent kinetic energy and turbulent magnetic energy .e. for small values of the magnetic Reynolds number). It is ubsequently proved that it is plausible to extend to the dissi- ative region the classical "two-layers" model having the following roperties: (1) in the "inner layer" there is local quasi-equilibrium etween turbulent kinetic energy production, viscous dissipation and "electromagnetic" dissipation; (2) the outer layer preserves a wake- ype character and its viscosity effects can be neglected. In accor- lance with the above scheme, the modified forms of the "law of the vall" and of the "skin friction law" are derived and discussed. Practical instances are worked out for the flat plate by means of uitable extension of the Clauser–Ferrari technique, and the rela- ive results are interpreted in the light of the energy transfer in the nner layer. The paper ends with a general discussion of the eatures of other turbulent dissipative regions of conducting fluids uch as the compressible boundary layer, the mixing regions, the vakes and the flow in pipes. Some remarks are also presented for he case in which the exchange between turbulent kinetic and mag- etic energies cannot be considered negligible.

5551 TRANSITION FROM LAMINAR TO TURBULENT FLOW IN MAGNETO-FLUID MECHANIC CHANNELS.

.S.Lykoudis.

ev, mod. Phys. (USA), Vol. 32, No. 4, 796-8 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). n attempt is made to establish a theoretical criterion in the case vhen a magnetic field is acting perpendicularly to the flow and the valls of the channel are electrically insulated. The existence of a aminar sublayer in the channel is postulated, assuming for this egion the validity of the laminar solution found by Hartmann and azarus (1937). It is found that the nondimensional number $\equiv M/Re(Cf)^{1/2}$, where M is the Hartmann number, Re is the eynolds number and Cf the skin friction coefficient, is the para- neter describing these laminar profiles in the classical $^+ = u/(\tau_W/\rho)^{1/2}$ versus $y^+ = \rho/\mu(\tau_W/\rho)^{1/2}y$ plane. Assuming the xistence of a laminar sublayer and a turbulent region (no buffer ayer), the maximum value for λ above which the turbulent region anishes is equal to 0.065; the ratio Re/M corresponding to this alue is equal to 236. This number is an excellent agreement with vailable experimental data based on the measurement of skin riction coefficients. It is shown that the turbulent regime cannot be lescribed by the parameter λ only. One more parameter is neces- ary and in this sense one-parameter universal solutions do not xist in the magnetic case.

5552 ON THE HYDROMAGNETIC FLOW DUE TO AN OSCILLATING PLANE.

R.Hide and P.H.Roberts.

ev. mod. Phys. (USA), Vol. 32, No. 4, 799-806 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). n order to understand the effect of viscosity in modifying the notion of a fluid in contact with vibrating solids, Stokes examined e particularly simple case of the flow of a fluid occupying the egion $z > O$ generated by the harmonic oscillation of the plane = z parallel to itself, in the x direction (say). In this paper the ffect on the motion of a uniform magnetic field parallel to the axis s examined, the analysis covering a wide range of appropriate undquist and magnetic Reynolds numbers, and being restricted to e case where $z > O$ is occupied by an insulator, and insulating urfaces are present at $y = \pm \infty$. In addition, the effect of Coriolis orces on this hydromagnetic flow is investigated, because of its ossible bearing on the study of the Earth's liquid core.

5553 ENERGY SPECTRA IN MAGNETO-FLUID DYNAMICAL TURBULENCE.

T.Tatsumi.

ev. mod. Phys. (USA), Vol. 32, No. 4, 807-12 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). his paper is concerned with the isotropic turbulence in an incom- ressible viscous electrically conducting fluid. Detailed discussions are made in relation to the steady states of turbulence which may be attained at extremely large Reynolds numbers R $(=[u^2]^{1/2}/\nu k_0)$, $\frac{1}{2}u^2$ = = the kinetic energy per unit mass, ν = the kinetic viscosity, k_0 = = the characteristic wave number. Steady states are possible for two ranges of the non-dimensional time t $(=\nu k_0^2 t)$: (1) $\tau \ll 1$, (2) $\tau \gg 1$. For the non-magnetic case, the kinetic energy spectrum E(k) is given by (1) $E(k) = Ak^{-2}$, (2) $E(k) = Ak^{-1}$, respectively. For the magnetic case, it is shown that the solution must be of the form: $E(k) = Ak^{-p}$, $H(k) = Bk^{-p}$, where H(k) is the magnetic energy spec- trum. In the case (1) it is found that no choice of the constants A, B and p cannot satisfy the equations for E(k) and H(k). The existence of the steady solutions and the possibility of the "turbulent dynamo" are discussed for the case (2).

5554 STABILITY OF A HOLLOW MERCURY JET.

B.Lehnert and G.Sjögren.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 813-14 (Oct., 1960).

Magneto-fluid Dynamics Symposuim (see Abstr. 4700 of 1961). Electric current is sent through a hollow jet of mercury which is flowing over the surface of a glass tube. The jet is broken up by the action of the electrodynamic force. However, if at the same time a strong current is sent through a central conductor placed inside the glass tube, the jet can be stabilized. This occurs when the currents are parallel. Sausage instabilities have not been observed in the present experiment.

5555 TWO-DIMENSIONAL LAMINAR BOUNDARY-LAYERS AND JETS IN MAGNETO-FLUID DYNAMICS.

G.Jungclaus.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 823-7 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The equations are studied for two-dimensional incompressible laminar boundary-layer flow under the influence of a magnetic field having a direction coincident with the plane of the flow. The outer velocity distributions and magnetic fields have been found for which the necessary condition for the existence of the so-called "similar" solutions to the boundary-layer equation are fulfilled. Simple analytical solutions are obtained for some specific distributions in the boundary-layer flow along bodies in jet flow into a medium at rest and in jet flow into a medium with pressure gradient. A comparison of these solutions with the corresponding ones for the ordinary hydrodynamics (without magnetic field) provides some insight into the influence of the magnetic field on boundary-layers.

5556 REDUCIBLE PROBLEMS IN MAGNETO-FLUID DYNAMIC STEADY FLOWS.

H.Grad.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 830-47 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The conventional equations describing the flow of a perfectly conducting fluid can be considered to be a sixth order system. This is reflected in the presence of three characteristic cones (or propagation speeds). The propagation of waves in a medium of infinite extent has been extensively studied, but boundary value problems offer much more difficulty. Several general classes of steady flow problems are considered which reduce to either the mathematical equivalent of a conventional fluid dynamics problem or to the relatively tractable problem of solving an essentially second order system. One example is a two-dimensional flow transverse to a unidirectional magnetic field (reducible to ordinary fluid dynamics). Another example is flow subject to the constraint that the magnetic field is everywhere parallel to the flow velocity (essentially second order). An approximate uncoupling into three distinct second order systems is found in certain limiting cases such as large and small magnetic fields. A complete separation into uncoupled second order systems is always possible when there are only two independent variables. However, even when the equations separate, simple mathematical techniques cannot always be found unless the boundary conditions split into groups in just the way as do the equations. This analysis separates out those problems which are accessible to more-or-less conventional mathematical techniques from those which will require basically new tools.

5557 SOME EXACT SOLUTIONS IN LINEARIZED MAGNETO-AERO DYNAMICS FOR ARBITRARY MAGNETIC REYNOLDS NUMBERS.

E.L.Resler, Jr and J.E.McCune.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 848-54 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). An equation for the electrical current in compressible linearized magneto-aero dynamic flows with arbitrary scalar electrical conductivity is given. The equation is applied to discuss the physical reality of forward facing waves in magneto-aero dynamics. The flow field over a wavy wall is discussed as a function of magnetic Reynolds number and the drag on the wall is plotted.

5558 MOTION OF BODIES THROUGH CONDUCTING FLUIDS. K.Stewartson.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 855-9 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The motion of a body through an inviscid fluid of conductivity σ in a direction parallel to that of a strong imposed magnetic field is studied. The equation of motion and the boundary conditions are set out and it is shown that the problem of steady motion is indeterminate if the disturbance caused by the body is permitted to extend to infinity. Through a study of initial motions it is shown this must in fact happen but that the ultimate steady motion can be found. It is noted, however, that the form of the final motion of the fluid crucially depends on whether σ is finite or infinite, being substantially different in the two cases. The reason is that two limiting processes are being undertaken at this stage, $\sigma \to \infty$, $t \to \infty$, t being the time, and the form of the motion depends on t/σ.

5559 MAGNETOHYDRODYNAMIC WAKES IN A VISCOUS CONDUCTING FLUID. H.Hasimoto.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 860-5 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The two-dimensional flow of an incompressible viscous fluid with finite electric conductivity is considered. It is assumed that both the magnetic field and the velocity vector are in the plane of the flow and each one reaches a constant value at infinity. A disturbance is placed at the origin and small perturbation technique is used to find the disturbance velocity and magnetic field. Explicit formulae are obtained in three special cases: (1) the undisturbed velocity and magnetic field are parallel. (2) The magnetic Prandtl number λ is unity. (3) The Stokes flow in which the undisturbed velocity U is very small compared to the Alfvén wave propagation speed, a. The most striking novel feature is the formation of two wakes instead of one and these in general point in two different directions. The well-known integral formulae of Kutta, Joukowski and Filon (1926) for the computation of the total force exerted on the disturbance now have been extended to these magnetohydrodynamic cases. As an illustrating example, the lift and the drag on a circular cylinder were determined for low Reynolds numbers (both viscous and magnetic) compared to unity. Case (1) is considered at some length. It is found that the upstream wake appearing for $U < a$ is dominant in the total mass flux and the total magnetic flux along the wake compared with the downstream wake, except for the case of $a/U \gg \lambda^{\pm 1/2}$, in which both wakes have equal strength.

5560 SOME REMARKS ON HYDROMAGNETIC WAVES FOR FINITE CONDUCTIVITY. E.L.Resler, Jr.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 866-7 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Using an equation governing plane wave propagation in an isotropic electrically conducting medium, the wave damping due to finite conductivity is determined. The effect of damping on the existence of "forward facing waves" is discussed making use of an appropriate "Friedrichs diagram". A criterion for recognizing forward facing waves from the phase velocity curve is given.

5561 ON THE THEORY OF PROPAGATION AND DECAY OF HYDROMAGNETIC WAVES IN AN ANISTROPIC MEDIUM. S.A.Kaplan.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 881 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). A study of the propagation of hydromagnetic waves in a medium with anisotropy due to the presence of a strong magnetic field. The structure of oblique shock waves in hydromagnetics is also discussed.

5562 MECHANICAL ANALOGY OF THE HALL EFFECT. L.J F.Broer.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 888 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). When a plasma is driven by a pressure gradient in x-direction through a magnetic field in z-direction the resultant motion will have a component in y-direction. In a simple case the angle between force and motion has been found to be $\omega\tau/2$ (ω cyclotron frequency, τ mean collision time).

5563 ON HYDROMAGNETIC STABILITY OF STATIONARY EQUILIBRIA. E.Frieman and M.Rotenberg.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 898-902 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Kulsrud (Abstr. 4159 of 1958) on an energy principle for hydromagnetic stability problems was restricted to the case of static equilibria. It is, therefore, of interest to investigate hydromagnetic stability when this restriction is removed. A general sufficient condition for stability has been found which applies to stationary equilibria. The sufficient condition leads to the following theorem: If a static equilibrium state is stable, the addition of any velocity small compared to both sound and Alfven speeds, leaves the system stable. If the static equilibrium state is neutral, a simple necessar and sufficient condition for stability has been derived. This condition leads to a proof that, to lowest order in the parameter of smallness, overstability cannot occur if the system is non-degenerate. If the static equilibrium state is unstable, a small veloci field can produce overstability. Some variational principles are be discussed.

5564 ON THE STABILITY OF A PERIODIC FORCE-FREE FIELD WITH NEUTRAL LINES. E.Schatzman.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 903-6 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr.4700 of 1961). The field is supposed to be independent of z but is periodic in x and y; m and n being integers, the field has neutral lines along the z axis for the following coordinates:

$$kx = [m + (1/2)]\pi,$$
$$ly = [n + (1/2)]\pi,$$

k and l being the wave-numbers of the periodic structure. Fourier analysis of a perturbation leads to sufficient conditions for instability: (1) if H is a characteristic value of the magnetic field, and p the gas pressure, then $H^2 > C_1 p$, where C_1 is a constant of order unity. (2) If the magnetic field is periodic, as in (1), the instability occurs for perturbations which are subharmonics of the magnetic field. (3) If the wave-number of the perturbation in the z direction is smaller than either α (characteristic scale of the force-free field) or $C_2\alpha(H^2/p)^{1\ 2}$, where C_2 is a constant, a "kink instability" occurs.

5565 STABILITY OF TWISTED MAGNETIC FIELDS IN A FLUID OF FINITE CONDUCTIVITY. R.J.Tayler.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 907-13 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The perturbed equations for a cylinder of incompressible fluid of finite electrical conductivity and viscosity carrying a uniform axia current and a uniform axial magnetic field can be formally solved in terms of Bessel functions. The stability problem is then reduc to the solution of an extremely complicated transcendental dispers relation. In some special cases this dispersion relation can be solved. If there is no axial field and only axi-symmetric perturbations are considered it can be solved completely. In the general case solutions can be obtained for very high and very low conductivity and for particular perturbations which exactly follow the field lines. It is shown that the introduction of viscosity exerts a stabilizing effect but that a fluid of finite conductivity may be less stabl than a fluid of infinite conductivity. This is not surprising because for an incompressible fluid, the conductivity only enters the stabili problem through the magnetic field diffusion equation where it allo the fluid to move across the lines of magnetic force.

5566 ON THE THEORY OF HYDROMAGNETIC EQUILIBRIUM L.Woltjer.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 914-15 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Invariants of the hydromagnetic equations, without dissipative term are discussed. The applicability of these invariants in a more general plasma (two fluid model) is investigated. An outline is giv of a systematic theory of hydromagnetic equilibrium and stability b means of variational principles and based on the existence of these invariants. The advantages and limitations of such a theory are briefly discussed.

5567 ON THE MAGNETODYNAMIC AND ADIABATIC EQUILIBRIUM OF A GASEOUS MASS WITH A UNIFORM ROTATIONAL AND GRAVITATIONAL MOTION. C.Agostinelli.

Rev. mod. Phys. (USA), Vol. 32, No. 4, 941-6 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The equations are established of adiabatic equilibrium of a gaseous mass with an infinite electrical conductivity, such as, a very hot stellar mass rotating with uniform speed around an axis passing through its barycenter and subjected to Newtonian attractive forces between single fluid particles, with the assumption that conductivity currents generate a magnetic field. It is demonstrated that the fiel must be symmetrical with respect to the rotational axis and the problem is reduced to the integration of two partial differential equations with two unknowns, of which one can be called the field-function and the other the fluid density. In the particular case in which the transverse component of the magnetic field is zero, the field-function can be eliminated the problem reduced to a partial differential equation of fourth order where only the fluid density is unknown.

5568 SHOCK WAVES AND SHOCK WAVE STRUCTURE IN MAGNETO-FLUID DYNAMICS. P.Germain.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 951-8 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The fundamental properties of shocks as discontinuities in a perfect fluid flow and the structure of the shock layer are studied, when taking account of the dissipative effects. These effects introduce 4 coefficients: viscosity (2), thermal conductivity, and the inverse of the electrical conductivity. No special assumption is made regarding the behaviour of these coefficients with respect to the physical quantities. For a given mass, momentum, and energy flux, there exist at the most 4 states which may be connected through a shock: S_1, S_2, S_3, S_4; the value of the index being an increasing function of the entropy. A "Fast Shock" ($S_1 \rightarrow S_2$) is stable, i.e., is a limit of "shock layers" when arbitrary dissipative coefficients are vanishingly small. An "Intermediate Shock" ($S_1 \rightarrow S_3$ or S_4; $S_2 \rightarrow S_3$ or S_4) is never stable. A "Slow shock" ($S_3 \rightarrow S_4$) may be stable.

5569 ATTACHED STATIONARY SHOCK WAVES IN IONIZED GASES. H.Cabannes.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 973-6 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). In a compressible fluid of infinite electrical conductivity, the problem of the attached stationary shock wave at the leading edge of a wedge is treated for the case of a zero electric field. The general case is related to the above by change of reference axes. Five shock waves can be obtained; the fast shock is always detached for angles greater than the maximum obtained in classical aerodynamics, instead the slow shock can be attached for these conditions. The boundary curves of the regions in which the shock waves are detached have important differences for weak magnetic fields and for strong magnetic fields. In all cases the presence of a magnetic field has the effect of increasing the drag, and lowering the temperature and the aerodynamic pressure.

5570 ON GAS-IONIZING MAGNETOHYDRODYNAMIC SHOCK WAVES. A.G.Kulikovskii and G.A.Lyubimov.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 977-9 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The structure of shock waves is considered which ionize the gas through which they propagate. The electrical conductivity is supposed zero ($\sigma_1 = 0$) in front of the shock wave and non-zero behind it ($\sigma_2 \neq 0$). It is assumed that the vectors of magnetic and electric fields are perpendicular to each other and parallel to the plane of the shock wave. It is shown that not all discontinuity surfaces satisfying conservation laws can be considered to be limiting cases of continuous flow representing the structure of the shock waves when dissipative coefficients tend to zero. It is pointed out that in order to obtain shock waves which may be considered as limiting cases of continuous flow it is necessary to introduce a supplementary boundary condition. A method is suggested of obtaining this boundary condition. The supplementary condition permits the unique solution of nonsteady problems (e.g. the piston problem) and allows the intensity of the electromagnetic wave which propagates in front of the shock wave in the problems when $\sigma_1 = 0$ to be obtained.

5571 SOME GENERALIZATIONS IN ONE-DIMENSIONAL MAGNETO-GAS DYNAMICS. J.A.Shercliff.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 980-6 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Develops a simple theory of magneto-gas dynamics, without the assumption of perfect gas behaviour, for the case of one-dimensional flows under a transverse magnetic field. The vital distinction is made between approximate one-dimensional flows (where transverse electric and magnetic fields and area changes may be imposed, and the ordinary sound speed is critical) and strict one-dimensional flows, where the augmented, magnetic sound speed is critical. The section on strict one-dimensional flows deals with steepening of simple compressive waves, magnetic Rayleigh and other processes and the use of the Rayleigh line to determine possible shock transitions. Finally, shock structure is studied in the three cases where one of the three diffusivities, thermal, magnetic and viscous, far exceeds the other two. In each case, the behaviour is qualitatively similar to that of a perfect gas provided the gas obeys certain simple conditions.

5572 ON FLOW THROUGH DIRECT-CURRENT ELECTROMAGNETIC PUMPS. V.J.Rossow.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 987-91 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). Experimental and theoretical studies of the flow fields induced by devices such as the arc jet, electromagnetically driven shock tubes and plasma drives show their behaviour to be too complex to afford a simple and instructive analysis. Therefore, in order to isolate and study the effect of electromagnetic body forces in a simple way, experiments have been carried out with a d.c. electromagnetic pump which moves a stream of salt water through a channel. Ink filaments injected into the stream ahead of the pump identify the motion of the fluid elements through the pump. Predicted and measured results for various magnetic and electric field configurations demonstrate the effects of several design features on the flow out of the pump.

5573 ON FLOWS OF CONDUCTING FLUIDS PAST BODIES. I.Imai.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 992-9 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). First, the general three-dimensional flow of a compressible, inviscid, perfectly conducting fluid in the presence of uniform magnetic field is considered when the undisturbed flow and magnetic field are parallel. It is shown that the flow is essentially similar to the ordinary flow of a hypothetical non-conducting gas with an appropriate pressure-density relation. Thus, approximate methods of treating such magneto-hydrodynamic flows can be developed along a line similar to the von-Karman—Tsien approximation for plane gas flows. As an example, Resler's equation for small-perturbation compressible plane flows can be derived as a special case. Second, general considerations are given to the small-perturbation theory of magnetohydrodynamic flows at large or small magnetic Reynolds numbers. In particular, using the Stokes type approximation, the general expressions are obtained for the velocity and magnetic field as well as for the force and moment acting on a body submerged in the flow at small magnetic and ordinary Reynolds numbers. As an example of application, the force and moment experienced by a sphere moving in an arbitrary manner (translating and rotating) in a uniform magnetic field are explicitly calculated.

5574 INVISCID FLOW PAST A BODY AT LOW MAGNETIC REYNOLDS NUMBER. G.S.S.Ludford.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 1000-3 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The flow of an incompressible, inviscid, electrically conducting fluid past a body depends on the two parameters: the magnetic Reynolds number R_M, and β, the ratio of a representative magnetic pressure to the free-stream dynamic pressure. In the present paper assuming R_M is small two cases are considered: (1) β small; weak magnetic field originating inside the body, (2) $\beta.R_M$ large; very strong magnetic field applied at right angles to the motion. In particular, formulae for the drag coefficient are given; in the first case it is proportional to $\beta.R_M$ and in the second to $\sqrt{\beta R_M}$.

5575 MAGNETOHYDRODYNAMIC HYPERSONIC FLOW IN THE QUASI-NEWTONIAN APPROXIMATION. R.X.Meyer.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 1004-7 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). The theory of the approximation to the flow about a body of revolution is developed. The applied magnetic field is rotationally symmetric, but otherwise arbitrary. The electrical conductivity is assumed to be scalar, but may be an arbitrary function of temperature and density. The limiting case is considered in which the density ratio across the shockfront tends to infinity ("quasi-Newtonian approximation"). The results are applied to the circular cone. A similarity solution valid for finite and variable conductivity is obtained.

MAGNETOHYDRODYNAMIC SHOCK WAVE IN A COLLISION-FREE PLASMA. See Abstr. 5453

HYDROMAGNETICS AND STELLAR STRUCTURE. See Abstr. 5156

ELECTROMAGNETIC WAVES AND OSCILLATIONS

(See also Plasma Oscillations)

5576 AN ESTIMATION OF SMITH—PURCELL EFFECT AS THE LIGHT SOURCE IN THE INFRARED REGION.

K.Ishiguro and T.Tako.
Optica Acta (Internat.), Vol. 8, No. 1, 25-31 (Jan., 1961).

The Smith—Purcell effect occurs when an electron beam streams along the surface of a metallic diffraction grating. The wavelength of the emitted e.m. wave is estimated by the formula devised originally by Smith and Purcell from Huygens' principle. In the present paper, an alternative derivation of the formula is presented under the assumption that the radiation is dipole radiation from a travelling dipole consisting of an electron and its image charge. The intensity of the radiation and the effect of the shape of the grating groove on the radiation are also calculated. The results of a preliminary experiment are compared with the calculation.

5577 GENERATION OF MICROWAVE ELECTROMAGNETIC RADIATION IN MAGNETIC MATERIALS.

J.H.Rowen, F.G.Eggers and W.Strauss.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 313S-315S (March, 1961).

A novel method of generating microwave and millimeter wave radiation in magnetic materials through the influence of high-intensity mechanical vibrations is described. Measured values of the static strain dependence of cubic ferrite materials are used to illustrate the principle, and arguments are presented extending this method to millimeter wave generation in antiferromagnetic materials.

5578 USE OF A Y-TYPE CIRCULATOR SWITCH WITH A 21-CENTIMETER MASER RADIOMETER.

B.F.C.Cooper.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 202-3 (Feb., 1961).

5579 STANDARDIZATION OF STRONG ELECTROMAGNETIC FIELDS. J.A.Lane and J.E.Pearson

Nature (GB), Vol. 189, 49-50 (Jan. 7, 1961).

A parallel-plate transmission line was used at around 1.0 Gc/s to give a standard flux density of the order 10 mW/cm^2. This could be used to calibrate monitoring instruments used in the vicinity of high-power transmitters. D.Walsh

5580 MEASUREMENTS ON POWER-CONVERSION GAIN AND NOISE RATIO OF THE 1N26 CRYSTAL RECTIFIERS. A.Dymanus and A.Bouwknegt.

Physica (Netherlands), Vol. 26, No. 2, 115-26 (Feb., 1960).

Measurements were performed on power conversion gain G and noise ratio n of a number of 1N26 silicon rectifiers (Sylvania Co., U.S.A.) using well-known techniques. The noise ratio was investigated both with microwave excitation (10^{-6}-10^{-3} W at 24 Gc/s) and with d.c.-excitation by currents up to 100 μA in the forward direction and up to 20 μA in the backward direction. The results (relative error 5-15%, estimated absolute error 25-30% for microwave excitation and about 15% for d.c. excitation) confirm the inverse-frequency dependence of n in the frequency region from 100 c/s-455 kc/s and the independence of G ($\sim$ 0.2 for sensitive rectifiers) of microwave power at powers higher than about 3×10^{-4} W. There is, however, a considerable discrepancy between the present results and the results of other investigators on G at powers below $\sim 3 \times 10^{-4}$ W, and on power and d.c. current dependence of n for microwave and d.c. excitation, respectively. A possible explanation is suggested for the discrepancy of the power dependence of n. However, no explanation can be given of the saturation of n at d.c. excitation by currents in the forward direction through sensitive rectifiers. No n-saturation was observed at microwave excitation.

5581 DISTRIBUTED AMPLIFIER FOR PULSES IN THE MILLIMICROSECOND REGION. F.Ţintă.

Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 2, 290-3 (1958).
In Roumanian.

Developed for spectrometric measurements of fast neutrons the amplifier, which uses nine selected EF 80 valves, gives a bandwidth of 320 Mc/s with variations of +0.5 and −2.5 dB. Filter sections are m-derived with $m = 1.27$, the end sections having $m = 0.6$ for best match into 90 ohm terminations. The calculated gain of 9.5 dB is achieved. Circuit diagram and design parameters are given. It is concluded that the same gain with larger bandwidth can only be attained by using a smaller number of high-slope valves, e.g. four E 180 F valves. A.Reiss

5582 THEORETICAL AND EXPERIMENTAL CHARACTERISTICS OF A FERROMAGNETIC AMPLIFIER USING LONGITUDINAL PUMPING. R.T.Denton.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 300S-307S (March, 1961).

A ferromagnetic parametric amplifier requiring fractional watts of pump power was developed and investigated experimentally. The amplifier employs magnetostatic modes as resonances which are parametrically pumped by a longitudinal r.f. magnetic field. A theoretical discussion of the characteristics of longitudinal parametric pumping on the magnetostatic modes is presented including selection rules for determining which pairs of modes can be pumped and an expression for the threshold pump field required for pumping the modes to oscillation. A relation for the gain-bandwidth product of the amplifier is derived, and it is shown how the coupling to the modes must be adjusted to maximize the gain-bandwidth. A model of the amplifier was built which utilizes X-band pump power and amplifies at C-band frequencies. The signal circuit is a coaxial line with a loop connected from the centre conductor around a sphere of yttrium iron garnet providing coupling to the magnetostatic modes. Results are presented of measurements at two different pump frequencies. In addition, several mechanisms are suggested as possible sources of noise in this amplifier.

5583 CURRENT WAVES IN A THIN CYLINDRICAL CONDUCTOR. III. VARIATIONAL METHOD AND ITS APPLICATION TO THE THEORY OF IDEAL CONDUCTORS AND OF CONDUCTORS WITH IMPEDANCE. L.A.Vainshtein.

Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 29-44 (Jan., 1961). In Russian.

For Pt II, see Abstr. 7219 of 1960. A method of successive approximations, based on the variational principle, is formulated. It is shown that even the first approximation of this variational method gives a good approximation and a fairly simple formula for the slowly varying function, which determines the current waves in a thin cylindrical conductor; this function can also be found for a conductor with a finite linear impedance. The variational method is used also to obtain a simple approximate expression for the propagation characteristics of a plane electromagnetic wave along a semi-infinite conductor. [English translation in: Soviet Physics—Technical Physics (USA)]. J.K.Skwirzynski

5584 CURRENT WAVES IN A THIN CYLINDRICAL CONDUCTOR. IV. AERIAL INPUT IMPEDANCE AND THE ACCURACY OF FORMULAE. L.A.Vainshtein.

Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 45-50 (Jan., 1961). In Russian.

A complex parameter, determining the input impedance of an infinite wire, is tabulated and investigated; it is shown that this parameter can also be used to calculate the input impedance of a transmitting aerial in the form of a thin straight conductor of a finite length. The accuracy of formulae obtained previously (Abstr. 7218-19 of 1960) is discussed again. [English translation in: Soviet Physics—Technical Physics (USA)]. J.K.Skwirzynski

5585 THEORY OF A MODIFIED SPIRAL WITH REVERSE WINDING. S.S.Kalmȳkova and V.P.Shestopalov.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 813-16 (Aug. 1, 1960).
In Russian.

For abstract, see Abstr. 17111 of 1960. [English translation in Soviet Physics—Doklady (USA), Vol. 5, No. 4, 873-6 (Jan.-Feb., 1961)].

5586 MEASUREMENTS OF THE ENERGY OF A LARGE RADIATOR AT 3 cm WAVELENGTH. V.P.Bȳkov.

Radioteknika i Elektronika (USSR), Vol. 4, No. 1, 145 (Jan., 1959).
In Russian.

Measurements were made on a spark discharge device consisting of 72 steel balls of diameter 3.18 mm arranged in six parallel chains spaced 12 mm from each other, the distance between the balls being 3.3 mm. The system was fed from a 15 kV pulsed supply. Power of about 0.5 μW was measured at 3.2 cm. The power depended on the nature of the surrounding gas but depended little on the supply conditions. R.C.Glass

SUPERCONDUCTORS AS QUANTUM DETECTORS FOR MICRO-WAVE AND SUB-MILLIMETER-WAVE RADIATION. See Abstr. 5400

5587 FINE-WIRE FERRITE LIMITER.

E.Stern.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 315S-317S (March, 1961).

The subsidiary resonance observed in ferrite at high microwave magnetic field intensities is suitable for limiting purposes. The limiter threshold power is related to the units of magnetic field intensity produced in the ferrite per unit of power input. The circumferential field about a wire is directly proportional to the current and inversely proportional to the wire diameter. Thus a fine wire embedded in ferrite will produce intense microwave fields at low microwave power levels provided that the wire is properly matched to the microwave structure. The response of a ferrite limiter to a microwave pulse characteristically exhibits a leakage spike and a plateau whose power level is proportional to ΔH_K^2. Thus, low threshold power levels normally can be achieved with narrow-linewidth materials. The fine-wire technique is analysed for limiter applications and it is shown that threshold power levels less than 1 W can be achieved in ferrite with wide linewidths. Particular structures were designed, built, and evaluated. It was found that a threshold power level less than 1 W was achieved, and that the spike duration decreases rapidly with increasing power.

5588 TRAVELING-WAVE FREQUENCY DOUBLING IN FERRITES.

B.A.Auld, H.J.Shaw and D.K.Winslow.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 317S-318S (March, 1961).

A perturbation analysis was made of frequency doubling in a ferrite-loaded rectangular waveguide. These calculations give quantitative predictions for second-harmonic power output as a function of various parameters. The values and range chosen for these various parameters are the same as used in experiments which were performed to check the theory. Good correlation was obtained between experimental results and second-order perturbation theory.

5589 PHASE SHIFT STUDIES IN FERRITE—DIELECTRIC LOADED COAXIAL LINES AT 2200 Mc/s.

J.J.Rowley.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 321S-322S (March, 1961).

Results are presented of an experimental study which was undertaken to determine the parameters which affect total and differential phase shifts in ferrite—dielectric loaded coaxial lines. The dependence of phase shift per unit length on the parameters of dielectric angle, ferrite cross-sectional area, and d.c. magnetic field are shown for a $\frac{7}{8}$ in. coaxial line. These experimental results are compared to those computed by Button for a $1\frac{5}{8}$ in. coaxial line and found to agree quite well qualitatively. Differential phase shifts of 300° per dB loss were obtained for the best experimental results, and the study showed that the theory developed by Button correctly predicts the parameters necessary to obtain large differential phase shift in ferrite—dielectric lines.

5590 COMPACT U.H.F. ISOLATOR.

D.B.Swartz.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 319S-320S (March, 1961).

The fundamental characteristics and structure of a strip transmission line isolator which operates to frequencies as low as 200 Mc/s are reported. This structure does not utilize dielectric material as a mode distorting material to create the necessary conditions for nonreciprocal wave propagation, but instead depends on the asymmetrical placement of the ferromagnetic material on the centre conductor. Isolation-to-insertion loss ratios of better than 36 to 0.4 dB were achieved at 725 Mc/s while isolation peaks of 35 dB to less than 1 dB insertion loss were obtained at frequencies as low as 375 Mc/s. The overall length of the device with the above characteristics was $6\frac{1}{2}$ in. and recent evidence indicates that this can be substantially reduced.

REFLECTION OF ELECTROMAGNETIC WAVES FROM A MOVING PLASMA. See Abstr. 5455

5591 DIFFRACTION IN A NON-UNIFORM FIELD.

V.P.Peresada.

Radiotekhnika i Elektronika (USSR), Vol. 4, No. 3, 384-7 (March, 1959). In Russian.

A general method for obtaining an approximate solution of the problem of diffraction by perfectly conducting bodies in a field in which surfaces of the same phase and amplitude are not in the same plane is given, based on Kirchoff's approximation method in vector form. The particular case of diffraction by a rectangular plate situated above the earth is considered. R.C.Glass

5592 THE DIFFRACTION OF ELECTROMAGNETIC WAVES BY DIELECTRIC OR SEMICONDUCTING SHEETS.

A.A.Pistol'kors, V.A.Kaplun and L.V.Knyazeva.

Radiotekhnika i Elektronika (USSR), Vol. 4, No. 6, 911-19 (June, 1959). In Russian.

The effect of dielectric sheets of finite dimensions on the field of a plane wave is studied theoretically using Kirchhoff's method and expressions are derived for the diffracted field. The results are extended to include semiconducting sheets. Diffraction from a half-plane and from a sheet of finite width are considered as special cases. The results are verified experimentally. R.C.Glass

5593 THE PROBLEM OF DIFFRACTION OF ELECTROMAGNETIC WAVES BY A PERFECTLY CONDUCTING PLANE RING.

G.A.Grinberg and E.N.Kolesnikova.

Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 13-17 (Jan., 1961). In Russian.

The wave incidence on the ring is normal; it is assumed that the internal radius a and the width b of the ring are much larger than the wavelength λ. Asymptotic solutions are obtained (with an accuracy of the order of $1/\delta^2$, where δ is less than both $\beta = 2\pi a/\lambda$ and $\beta' = 2\pi(b - a)/\lambda$) of the integral equation for the induced currents of the ring in the shadow region. [English translation in: Soviet Physics—Technical Physics (USA)]. J.K.Skwirzynski

EXACT SOLUTION OF WAVE SCATTERING BY IRREGULAR SURFACES. See Abstr. 5332

5594 GENERALIZATION OF THE CONDITION AT EDGES, IN THE CASE OF A TWISTED CURVE.

P.Poincelot.

C.R. Acad. Sci. (France), Vol. 251, No. 23, 2670-1 (Dec. 5, 1960). In French.

The author's previous work (Abstr. 15143 of 1960) on the electromagnetic boundary conditions is extended to the present case. The main conclusions still hold. P.M.Davidson

5595 FURTHER COMMUNICATION ON AN ELECTROMAGNETIC WAVE-FRONT IN AN IONIZED GAS SUBJECTED TO A MAGNETIC FIELD.

M.De Socio.

RC Accad. Naz. Lincei (Italy), Vol. 28, No. 5, 622-6 (May, 1960). In Italian.

Continuation of the work from a previous paper (Abstr. 11049 of 1960). The research is extended to the case when the dielectric constant of the gas is variable. G.Martelli

5596 GRAPHICAL DETERMINATION OF RADIO RAY BENDING IN AN EXPONENTIAL ATMOSPHERE.

C.F.Pappas, L.E.Vogler and P.L.Rice.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 175-9 (March-April, 1961).

Presents a simple engineering method for calculating the amount of bending undergone by a radio ray passing through an exponential model atmosphere. For any initial takeoff angle and for values of the surface refractivity ranging from 200 to 450, the bending angle τ may be determined as a function of height above the earth's surface, using a few graphs and a few calculations. Indications of the accuracy of the method are given.

5597 A FORMULA FOR RADIO RAY REFRACTION IN AN EXPONENTIAL ATMOSPHERE.

G.D.Thayer.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 181-2 (March-April, 1961).

A formula for the radio ray refraction angle, τ, is derived by integration of the approximate differential equation for the case where the refractivity, $(n - 1) \times 10^6$, decreases exponentially with height above the surface of a smooth, spherical earth. The solution is in terms of the widely tabulated exponential and error functions, and is accurate to within 4% over the useful range of the variables employed.

5598 PROPAGATION OF ELECTROMAGNETIC WAVES IN A PLASMA WITH STRONG MAGNETIC FIELD.

H.Poeverlein.

Phys. of Fluids (USA), Vol. 4, No. 4, 397-405 (April, 1961).

Formulations describing the propagation of electromagnetic waves in a cold plasma in the presence of a constant magnetic field H_0 become particularly simple in a limit case that corresponds to a high longitudinal conductivity component (component parallel to H_0)

and negligible transverse conductivity components. In this case, perfect guidance along the magnetic force lines is found for one propagation mode and propagation independent of direction for the other, characteristics known to appear in hydromagnetic waves. In the present case, however, no ion effects need to taken into consideration and the phase velocity is high, equaling vacuum velocity. Propagation of plane waves is treated and a wave-theoretical formulation is derived, valid for any wave field under the assumed conditions with a uniform magnetic field. A section on propagation in force line tubes includes some physical discussion. Comparisons are made between the present limit case and other limit cases of waves in plasmas, which have been thoroughly studied previously—hydromagnetic waves (without compressional forces) and ionospheric whistlers.

5599 THE MAGNETO-IONIC THEORY FOR DRIFTING PLASMA. H.Unz.
IRE Trans Antennas and Propagation (USA), Vol. AP-8, No. 5, 517 (Sept., 1960).

Quotes a formula for the refractive index of a magneto-ionic medium drifting with constant velocity, the derivation of which is to be published under the same title as the present note.
G.D.Sims

5600 THE ABSORPTION OF RADIO WAVES IN RESONANCE REGIONS OF A NON-HOMOGENEOUS PLASMA.
N.G.Denisov.
Radiotekhnika i Elektronika (USSR), Vol. 4, No. 3, 388-97 (March, 1959). In Russian.

The absorption of electromagnetic waves propagating in a plasma in which the electron concentration is such that one of the refractive indices is infinite is investigated, both for the case when interaction between the ordinary and extraordinary waves is neglected and when it is taken into account. The results obtained are discussed with reference to wave propagation in the ionosphere.
R.C.Glass

5601 FIELD-ALIGNED IONOSPHERIC IRREGULARITIES AND THE SCINTILLATION OF SATELLITE RADIO TRANSMISSIONS. D.G.Singleton, G.J.E.Lynch and J.A.Thomas.
Nature (GB), Vol. 189, 30-1 (Jan.7, 1961).

Observations at Brisbane of the random fading of transmissions from satellite Explorer VII, associated with propagation through ionospheric irregularities, suggest that the fading amplitude is more pronounced for propagation along the lines of the earth's magnetic field than for any other direction. This is probably associated with the possibility that for propagation along the field, radiation can reach the receiver by two different paths on account of the field-alignment of the irregularities. G.M.Brown

5602 RADIO-WAVE PROPAGATION IN THE EARTH'S CRUST. H.A.Wheeler.
J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 189-91 (March-April, 1961).

There is a reasonable basis for postulating the existence of a useful waveguide deep in the earth's crust, of the order of 2 to 20 km below the surface. Its dielectric is basement rock of very low conductivity. Its upper boundary is formed by the conductive layers near the surface. Its lower boundary is formed by a high-temperature conductive layer far below the surface, termed the "thermal ionosphere" by analogy to the well-known "radiation ionosphere" far above the surface. The electrical conductivity of the basement rock has not been explored. An example based on reasonable estimates indicates that transmission at 1.5 kc/s might be possible for a distance of the order of 1500 km. This waveguide is located under land and sea over the entire surface of the earth. It may be useful for radio transmission from the shore to a submarine on the floor of the ocean. The sending aerial might be a long conductor in a drill hole deep in the basement rock; the receiving aerial might be a vertical loop in the water.

Radiofrequency Spectroscopy Techniques

5603 MEASUREMENT OF THE WIDTHS OF MICROWAVE SPECTRAL LINES.
E.A.Rinehart, R.H.Kleen and C.C.Lin.
J. molecular Spectrosc. (USA), Vol. 5, No. 6, 458-73 (Dec., 1960).

The design of a microwave spectrograph constructed for precis measurements of line widths is described. The effects of microwave power, frequency and amplitude of the source modulation, and klystron mode curvature on the apparent widths of the spectral lines are investigated and methods for correcting the change of the widths due to these factors are given. It is found that source modulation by square wave yields more accurate data than by sine wave. From the general theory of frequency modulation in microwave spectroscopy, formulae are derived for the increase of the width due to the source modulation. These equations agree well with experimental results and may be used to calculate the true widths from the apparent widths.

5604 A HIGHLY-SENSITIVE PARAMAGNETIC [SUPERHETERODYNE] MICROWAVE SPECTROMETER FOR 9000 Mc/s. Ya.L.Shamfarov.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 57-61 (Nov.-Dec.). In Russian.

Stabilization of the klystron signal frequency with respect to the measuring resonator, as well as automatic trimming of the loca heterodyne frequency, is used in the spectrometer circuit. The latter permits the observation of the clear signal of paramagnetic resonance absorption (dispersion is eliminated) and suppresses the noise connected with fluctuations in the klystron and in the measuring resonator. [English translation in: Instrum. exper. Tech. (USA), No. 6, 916-21 (Nov.-Dec., 1959; publ. Sept., 1960)].

5605 HIGH LEVEL OSCILLATOR FOR NUCLEAR RESONANCE. W.D.Knight.
Rev. sci. Instrum. (USA), Vol. 32, No. 1, 95 (Jan., 1961).

A modification of the original circuit of Pound and Knight is described. It has the advantage of simplicity and works at higher levels and frequencies.
D.Wals

NUCLEAR PHYSICS

APPARATUS
PARTICLE DETECTORS

(Counting circuits are included under Electrical Measurements and Circuits)

5606 BORON TRIFLUORIDE PROPORTIONAL COUNTER OF GLASS. H.Fröhlich.
Exper. Tech. der Phys. (Germany), Vol. 8, No. 6, 241-7 (1960). In German.

Investigations were carried out into the development of counters made of boron-free glass, and whose counting properties do not change with storing time. The construction of these detectors and the preparation of the cathode layer (Cu, ZnO_2, or Pt) are described in detail. Special attention was given to the cleaning of the tube and the purity of the filling gas to minimize the chance of negative ion formation. The counter pressure, anode and cathode radius and operating potential were so chosen that the probability of electron survival from capture was greater than 0.5. Families of "characteristic" counting curves obtained one year after filling, and the effect of the anode wire eccentricity on the plateau length and slope are graphically shown. I.C.Demetsopoullos

5607 ON THE CONSTRUCTION AND LONG-TERM PERFORMANCE OF MEDIUM PRESSURE BF_3 PROPORTIONAL COUNTERS USED FOR COSMIC-RAY RECORDING. P.H.Stoker.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 23-6 (July, 1960).

Construction and filling procedure of BF_3 proportional counters for a cosmic-ray neutron monitor are outlined. The method of improvement of the operational characteristics of the counters necessitated by deterioration over the first years of continuous operation is given.

5608 THE EFFECT OF GAMMA-BACKGROUND ON THE BF_3 PROPORTIONAL COUNTER. J.Csikai and M.Buczko.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 73-5 (July, 1960).

The integral amplitude distribution of the BF_3 proportional counter was found to be affected by a strong gamma background. The distortion of amplitude distribution was investigated as a function of electronic amplification, using counters of different cathodes. The distortion may be explained by a positive space charge developing around the anode.

5609 THE CO_2 PROPORTIONAL COUNTER OF THE CARBON-14 DATING LABORATORY OF THE UNIVERSITY OF ROME. F.Bella and C.Cortesi.
Ricerca sci. (Italy), Vol. 30, No. 12, 1969-77 (Dec., 1960).

The carbon dioxide proportional counting system of the Carbon-Dating Laboratory at the University of Rome is described. The preparation and purification of CO_2 is carried out following the De Vries method with a few modifications. The proportional counter involves some original construction characteristics (background 1.75 c.p.m.; counting rate for modern carbon 12.08 c.p.m.; effective volume 1.580 litres). The shields are 27 cm thick iron and block of paraffin mixed with boric acid. The hard component of cosmic rays is anticoincided by means of a plastic scintillator.

5610 A CO_2 PROPORTIONAL COUNTER OF SMALL VOLUME AND HIGH EFFICIENCY FOR LOW LEVEL β-COUNTING. M.Alessio, L.Allegri and F.Bella.
Ricerca sci. (Italy), Vol. 30, No. 12, 1960-2 (Dec., 1960).

THE USE OF SPARK COUNTERS FOR THE DETECTION OF FAST NEUTRONS. See Abstr. 5739

5611 ENERGY RESOLUTION CORRECTION FOR SCINTILLATION SPECTROMETERS. L.B.Gardner.
IRE Trans nuclear Sci. (USA), Vol. NS-7, No. 4, 36-44 (Dec., 1960).

A computational scheme is presented for correcting the energy resolution of scintillation spectrometers. This scheme, unlike others previously published, appertains only to experimental data and does not rely on theoretical considerations of energy absorption within the scintillator. Applications to beta spectroscopy and analysis are included and a derivation of the ideal scintillation line and the various factors which in practice statistically modify the ideal shape is given.

5612 IMPROVED PERFORMANCE FROM SCINTILLATION SPECTROMETERS.
D.O.Wells, S.L.Blatt and I.F.Boekelheide.
Rev. sci. Instrum. (USA), Vol. 31, No. 10, 1163-4 (Oct., 1960).

Experimental results are given which show that the performance of a NaI:Tl crystal when used as a scintillation spectrometer — in particular, the resolution — is enhanced if reflective coatings are applied around the edge of the photomultiplier face plate. Experiments were conducted with two kinds of coatings: (a) white Tygon paint and (b) smoked MgO. The coatings minimize loss of light through the glass envelope of the photomultiplier. Using the photopeak from Cs^{137} gamma-radiation, the energy resolution was reduced from 7.9% to 7.5% and the pulse-height increased by 10% in a typical case using a Tygon coating. C.F.Barnaby

5613 INFLUENCE OF CRYSTAL FORM ON THE ENERGY AND TIME RESOLUTION OF A SCINTILLATION APPARATUS. G.Luck.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 249-54 (Aug., 1960).

A decrease of the number of reflections of photons in a scintillation crystal leads to smaller fluctuations in time and pulse amplitudes of the output signal. This is possible with special forms of the scintillator. This is of interest for large-dimension scintillators and high particle energies, and is a way of raising the energy and time resolution of a scintillation arrangement.

SCINTILLATION COUNTER SYSTEM FOR THE DETECTION OF POSITIVE AND NEGATIVE PIONS. See Abstr. 5772

SCINTILLATION DETECTOR WITH SELECTIVE SENSITIVITY TO π^--MESONS. See Abstr. 5773

5614 DESCRIPTION OF P—I—N JUNCTIONS USED AS DETECTORS OF NUCLEAR PARTICLES. SPECTROMETRY OF HIGH-ENERGY IONIZING PARTICLES. DETECTION OF γ-RAYS. L.Koch, J.Messier and J.Valin.
C.R.Acad. Sci. (France), Vol. 251, No. 25, 2912-14 (Dec. 19, 1960). In French.

The use of p—i—n junction structures made by diffusion into opposite sides of a silicon wafer 280 μ thick, as a particle detector is described. The sensitivity, linearity, and resolution of the devices are discussed. C.A.Hogarth

5615 HEAVY-PARTICLE DETECTOR USING A SILICON P—N JUNCTION.
G.Amsel, P.Baruch and O.Smulkowski.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 92-105 (July, 1960). In French.

Silicon p—n junctions were used to detect heavy charged particles produced by nuclear reactions inside an accelerator vacuum chamber, at room temperature. The response to particle energy dissipated in the barrier is linear. The width of resolved peaks at half maximum is independent of incident particle energy and is equivalent to 40 keV for α-particles, and 30 keV for protons and deuterons. The rise time of the signal due to particles stopped in the barrier is of the order of 1 mμsec while that due to particles traversing it has a slow component; this permits their distinction electronically. The detectors are insensitive to γ-rays and neutrons.

5616 RESPONSE OF SEMICONDUCTOR SURFACE-BARRIER COUNTERS TO NITROGEN IONS AND ALPHA PARTICLES. M.L.Halbert and J.L.Blankenship.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 106-16 (July, 1960).

Silicon and germanium surface-barrier counters for detection of short-range ionizing particles were constructed and tested. Measurements with artificial pulses showed that the barrier height V_0 is about 0.6 volts in Si, and that with variation of the applied bias V, the barrier capacity is linear with $(V_0 + V)^{-1/2}$ as expected from the Schottky exhaustion-layer theory. Measurements with natural alpha-particles showed that the charge-collection efficiency is probably 100%, the energy loss per electron—hole pair is 3.50 ± 0.05 eV in Si and 2.83 ± 0.03 eV in Ge, and the pulse-height resolution is outstandingly good. Two independent measurements with cyclotron-produced N^{14} ions up to 25 MeV showed that the pulse-height response is linear with energy. The ratio of N^{14} to alpha pulse height is equal to the energy ratio within 1%. The response to a continuous energy distribution of alpha-particles indicates that the sensitive depth is on the order of 20 μ greater than the barrier depth calculated from the Schottky theory. The excess sensitive depth probably represents diffusion into the exhaustion layer of holes produced below it.

5617 COUNTERS WITH LIQUID CIRCULATION. M.Weiner and D.Z.Niculescu.
Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 561-2 (1958). In Roumanian.

For the measurements on small volumes of liquid having low specific activity, counters were constructed which permit the introduction or circulation of the liquid between a cathode and an anode. Two types are sketched for γ and β radiations respectively. Very brief constructional details and working limits are given.

A.Reiss

Track Visualization

5618 A METHOD FOR FASTER ANALYSIS OF BUBBLE CHAMBER PHOTOGRAPHS.
P.V.C.Hough and B.W.Powell.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1184-91 (Dec. 16, 1960).

A measuring system is described which enables photographs of bubble chambers to be measured in a time ~ 30 sec per event. The design is such that the system can be developed in the direction of automatic pattern recognition without needing an on-line computer. Current difficulties and specific lines of future development are also discussed.

5619 FACTORS INFLUENCING PHOTOGRAPHIC SENSITIVITY TO NUCLEAR PARTICLES. G.Danguy.
Mem. Soc. Roy. Sci. Liège (Belgium), Coll. in-4, Vol. 2, No. 4, 27 pp. (1960). In French.

The sensitivity of pure AgBr emulsions to light, X-rays, alpha- and beta-particles was measured for five emulsions prepared with mixing times ranging from 100 sec to 180 min. The distribution of grain size was also measured for the five emulsions, and the mean size found to be roughly constant for the 100 sec-20 min mixing times, and some 20 times larger for 60 and 180 min. Sensitivity increased with mixing time, for all the radiations, and reached a constant value at about 20 min. No simple correlation was found between sensitivity and the projected area of the grains for any of the radiations.

E.J.Burge

5620 APPARATUS AND LABORATORY FOR PROCESSING NUCLEAR EMULSION STACKS.
H.Engelhardt, I.Hauser and U.Krecker.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 55-60 (July, 1960).

An apparatus is described for processing nuclear emulsion stacks with an area up to 35 × 45 cm^2. The apparatus is so constructed that 3.5 litres of emulsion, thickness 400 μ, can be processed during 5 days. The procedure for developing nuclear emulsions of type NIKFI R is presented.

5621 AN INSTRUMENT FACILITATING THE MEASUREMENT OF SMALL-ANGLE SCATTERING IN NUCLEAR EMULSION. A.G.C.Tenner, B.Jongejans and H.Witteveld.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 221-4 (Aug., 1960).

The instrument consists of a microscope and a mechanical recorder. Wiring diagrams are given. Experience obtained with the instrument in the first months of operation classifies it as a satisfactory new tool in nuclear physics. The principle underlying the instrument can be extended to bubble-chamber film.

EMULSION METHOD FOR THE ABSOLUTE MEASUREMENT OF THERMAL NEUTRON FLUX. See Abstr. 5735

NUCLEAR FIELD THEORY

5622 SPACE TIME REFLEXIONS, LIGHT QUANTA AND HEAVY BOSONS. H.Fröhlich.
Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 803-28 (1960).

A new approach to space—time reflections leads to the introduction of a new angular space in terms of which isobaric spin and related quantities find a simple explanation. On the basis of this new treatment, a wave-equation is presented which contains as a specific cases the Maxwell equations, and the wave-equations for π- and K-mesons. It also predicts the existence of a further partic with mechanical spin 1, with the same isobaric spin properties as K-mesons but with a larger rest mass.

RELATIVISTIC PARTICLE DYNAMICS. See Abstr. 5200

5623 STRUCTURE OF NON-RELATIVISTIC ANTI-TERMS. B.M.Stepanov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 547-9 (July 21, 1960). In Russian.

For abstract, see Abstr. 17224 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 709-12 (Jan.-Feb. 1961)].

5624 CORRESPONDENCE PRINCIPLE APPROACH TO RADIATION THEORY. F.E.Low.
Amer. J. Phys., Vol. 29, No. 5, 298-9 (May, 1961).

The classical law for the spontaneous radiation by a charged particle is expressed in such a way that its interpretation in terms of probabilities for transitions between stationary states is straightforward.

5625 A NEW MAJORANA FIELD THEORY. H.Umezawa and A.Visconti.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 262-82 (Jan., 1961).

After a short introduction the various isospin schemes for strong and weak interactions are reviewed and it is shown that they can be reduced to a common scheme by writing down an invariant of a set of 2 × 2 matrices, whose elements are linear combinations of the particle wave-functions. Various properties and difficulties of those schemes are discussed. A scheme is proposed where each set of a particle and its antiparticle is described by a quaternion. Several interesting properties of that scheme are pointed out: the rule for constructing quaternions leads directly to charge conserva tion; the strangeness conservation for strong interactions and the rule $|\Delta S| = 1$ for the weak interactions are direct consequences of this theory, furthermore all the unwanted electromagnetic interactions are naturally excluded.

5626 NON-LINEAR OSCILLATIONS IN WEAK EXTERNAL FIELDS, DESCRIBED BY LAGRANGE'S EQUATIONS. V.I.Gaiduk.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 4, 760-3 (Aug. 1, 1960). In Russian.

For abstract, see Abstr. 16602 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 713-17 (Jan.-Feb 1961)].

5627 ON THE CAUSALITY OF NONLOCAL FIELD THEORY. V.D.Sutula.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 77-80 (July 1, 1960). In Russian.

For abstract, see Abstr. 17206 of 1960. [English translation in Soviet Physics—Doklady (USA), Vol. 5, No. 4, 757-60 (Jan.-Feb., 1961)].

5628 THE S-MATRIX IN THE NON-LOCAL FIELD THEORY OF ARNOUS AND HEITLER. L.O'Raifeartaigh.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 783-802 (1960).

The general non-local field theory of Arnous and Heitler (Abstr. 9205 of 1959) is considered for a specially chosen c-number form factor. A technique for evaluating the S-matrix is developed and with its help it is proved that the theory is convergent throughout in all orders of perturbation. However, with this form factor strict Lorentz invariance is not maintained but is confined to the first order of perturbation, as some explicit calculations (e.g. the self-mass of the electron) show.

5629 CELLULAR SPACE-TIME AND QUANTUM FIELD THEORY. A.Das.

Nuovo Cimento (Italy), Vol. 18, No. 3, 482-504 (Nov. 1, 1960).

A simple cellular model of space-time is introduced which incorporates a fundamental length in a natural way. The usual concept of field quantities as functions of geometrical points is rejected in favour of the concept of field quantities as functionals of elementary cells. Consequently the usual field equations in the form of partial differential equations are replaced by corresponding partial difference equations. Subsequent quantization yields an S-matrix which is not vitiated by the presence of series divergences. The basic space-time structure and the S-matrix (which does not involve derivative coupling) are shown to be integral Lorentz covariant. The semi-convergence or asymptotic behaviour of the S-matrix series is established, and a meaningful Borel-sum of the "gross" S-matrix series is presented.

5630 A ONE-DIMENSIONAL SOLUBLE MODEL OF QUANTUM FIELD THEORY WITH EXTERNAL FIELD.

J.Šoln.

Nuovo Cimento (Italy), Vol. 18, No. 5, 914-27 (Dec. 1, 1960).

The one-dimensional model of interaction between the zero mass quantized Dirac field with a given time-dependent external field is solved exactly. The field operator ψ is given as a functional of the corresponding incoming field operator φ. The S operator is brought into the ordered form which gives the possibility of investigating any process for any strength of coupling. Finally, the vacuum-to-vacuum transition is compared with the results given by Neuman (Abstr 81, 1450 of 1952), Salam and Matthews (Abstr. 4615 of 1953).

5631 THE CONFORMAL INVARIANCE IN QUANTUM FIELD THEORY. J.Wess.

Nuovo Cimento (Italy), Vol. 18, No. 6, 1086-1107 (Dec. 16, 1960).

A short discussion of the conformal group in four dimensions and of the topology, introduced into the pseudo-euclidean space by this group is given. With the help of the commutation relations the spectrum of the generators in Hilbert-space is investigated. It is found that the only possible discrete eigenvalue of P^2 and of the P^{ν}'s is zero and that the generator for scale transformations S has a continuous spectrum. The eigenfunctions of S in the x-representation are calculated, they form a complete set. The conservation laws valid in an invariant theory and the commutation relations predict a certain form of the conserved quantities expressed in terms of the energy-momentum tensor and of the co-ordinates. For scalar, spinor and vector fields the generators are derived by the action principle of Schwinger.

5632 THE DETERMINATION OF A LOCAL OR ALMOST LOCAL FIELD FROM A GIVEN CURRENT.

H.Araki, R.Haag and B.Schroer.

Nuovo Cimento (Italy), Vol. 19, No. 1, 90-102 (Jan. 1, 1961).

It is shown that one cannot construct a local quantum field theory from a current operator which is a local polynomial of a free field. Secondly, the current of a local theory has to be complete or else the elastic scattering vanishes. These results do not depend in any essential way on the requirement of strict locality for the field but are only slightly modified if one allows "almost local" fields. The conditions which the current operator has to satisfy to ensure the existence of a local or almost local field are given.

5633 EQUIVALENCE THEOREMS AND RENORMALIZATION PROBLEM IN VECTOR FIELD THEORY (THE YANG—MILLS FIELD WITH NON-VANISHING MASSES).

H.Umezawa and S.Kamefuchi.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 399-429 (March, 1961).

Equivalence theorems are derived for the Yang—Mills field with non-vanishing masses and for the electrodynamics of vector fields. A general theory of the Stueckelberg formalism is also presented. On the basis of these theorems the renormalizability problem is discussed for the above cases. It is concluded that quite contrary to the case of a single real vector field, the theory is not renormalizable even when the source current of the field is strictly conserved. The origin of the non-renormalizability can always be traced back to the mass terms. Theorems are further generalized to the case of the intermediate vector particle theory of weak interactions.

5634 CANONICAL AND NON-CANONICAL METHOD OF QUANTISATION IN THE LEE MODEL. K.Sekine.

Nuclear Phys. (Internat.), Vol. 23, No. 2, 245-68 (Feb., 1961).

The connection between the canonical and the "non-canonical" method of quantization is studied with the help of the Lee model with indefinite metric. It is shown that, even when the anticommutator vanishes for equal times, it is still possible to construct a Hamiltonian formalism similar to the conventional one by introducing a small time interval Δt into some basic relations of the theory.

5635 NEW APPROACH TO PERTURBATION THEORY IN QUANTUM ELECTRODYNAMICS. I.Bialynicki-Birula.

Phys. Rev. Letters (USA), Vol. 5, No. 12, 584 (Dec. 15, 1960).

The ordinary Lagrangian of quantum electrodynamics is separated into a "free" part and an "interaction" part in a manner which differs from the usual one through the addition of a term $\Lambda^{-2}\bar{\psi}(i\gamma\cdot\partial - m)^3\psi$ to $\mathcal{L}_I$ and the subtraction of the same term from $\mathcal{L}_0$. The free equations for the electron field are solved exactly and lead to a propagator of the Pauli—Villars regularized form; an indefinite metric appears only for states of virtual particles. Setting $\Lambda^{-1} = E_{max}^{-1} e_0^{2(N+1)}$ where N is the highest order of perturbation theory and E_{max} the highest energy of a particle occurring in either the initial or the final states, the S matrix can be expanded as a power series in e_0, every term being finite. "All renormalization constants appear to have a singular dependence on the coupling constant of logarithmic type and they cannot be expanded into a power series in e_0." P.K.Kabir

5636 INFRARED PHENOMENA IN QUANTUM ELECTRODYNAMICS. I. THE PHYSICAL ONE-ELECTRON STATES IN THE INFRARED REGION.

W.van Haeringen.

Physica (Netherlands), Vol. 26, No. 5, 289-305 (May, 1960).

In view of remaining obscurities and diffculties in existing treatments of the infrared divergences in quantum electrodynamics this problem is reconsidered. The approximate model introduced in 1937 by Bloch and Nordsieck is rediscussed. It is explicitly shown to be a good substitute for the complete theory as long as one restricts oneself to infrared radiation. A non-covariant diagram technique is used to prove that neglect of recoil and pair effects is indeed allowed in the infrared radiation range. The effects of vacuum polarization and charge renormalization require special attention. They are treated in second order with the regularization method of Pauli and Villars.

5637 INFRARED PHENOMENA IN QUANTUM ELECTRODYNAMICS. II. BREMSSTRAHLUNG AND COMPTON SCATTERING. W.van Haeringen.

Physica (Netherlands), Vol. 26, No. 5, 306-25 (May, 1960).

The infrared aspects of quantum electrodynamics are discussed by treating two examples of scattering processes, bremsstrahlung and Compton scattering. As in Pt I a non-covariant diagram, technique is used which gives very clear insight in the cancelling of infrared divergences between real and virtual photons. The treatment of Compton scattering shows the necessity of reformulating a theorem of Thirring on the validity of the Thomson scattering formula at very low energies.

5638 MODEL OF A COULOMB CHARGE IN THE NONLINEAR FIELD THEORY. K.Bechert and J.Lindner.

Ann. Phys. (Germany), Vol. 6, No. 7-8, 361-9 (1960). In German.

It is shown that the nonlinear field theory by one of the authors [K.Bechert, Phys. Blatt. (Germany), Vol. 5, 380 (1949); Abstr. 73 of 1951; 35 of 1953; 5678 of 1956] has solutions corresponding to a charged particle of finite extension, the particle being held together by gravitational forces. W.A.Hepner

5639 GREEN FUNCTIONS OF THE MIXED CAUCHY PROBLEM OF THE GORDON—KLEIN EQUATION AND THEIR CONNECTION WITH ADVANCED AND RETARDED GREEN FUNCTIONS. R.Żelazny.

Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vol. 8, No. 10, 709-12 (1960).

The advanced and retarded Green's functions for the Klein—Gordon equation are derived as particular cases of a general expression which is obtained for the solution to this equation with Cauchy initial conditions. J.Hawgood

5640 ON CERTAIN REPRESENTATIONS OF THE DIRAC EQUATION. A.Chakrabarti.

Nuovo Cimento (Italy), Vol. 18, No. 4, 617-22 (Nov. 16, 1960).

By a generalization of the transformation given by Eriksen some representations of the Dirac equation are derived, particularly cases including the well-known ones of Foldy and Wouthuysen and of Cini and Touschek. A modification of the procedure gives a transformed Hamiltonian $\alpha_i E$ (i = 1, 2, 3), such that Γ_5 as defined by Cini—Touschek, has exactly the same form (namely $-\sigma p \lambda$), as in their case. Some special features of this representation are discussed.

5641 MINIMAL ELECTROMAGNETIC COUPLING FOR SPIN TWO PARTICLES. P.Federbush.

Nuovo Cimento (Italy), Vol. 19, No. 3, 572-3 (Feb. 1, 1961).

It is noted that if the same Lagrangian that describes the linearized theory of general relativity is extended to charged massed spin -2 particles the coupling cannot be minimal electromagnetic.

5642 ON NEUTRAL SPIN-0 PARTICLES WITH IMAGINARY PARITY. R.Spitzer.

Nuclear Phys. (Internat.), Vol. 21, No. 4, 681-5 (Dec. (3), 1960).

Some consequences of the existence of a neutral spin-0 particle with imaginary parity are examined. The particle is subsequently identified with K^0 and it is shown that associated production is a consequence of a superselection law for parity. The parity of the K^0 is fixed by its electromagnetic interaction, which leads to certain results that differ from those predicted by strangeness. The theory accounts directly for the nonconservation of parity in non-neutrino decays of Λ, Σ's and K's.

5643 CONNECTION OF SPINOR FIELDS. H.Nakamura and T.Toyoda.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 524-8 (Feb., 1961).

It is proved that the field introduced by the connection of γ_i matrices can be eliminated by a suitable gauge transformation except in the case of the gravitational and electromagnetic fields. Related papers are discussed.

5644 FERMIONS AND THE INTRINSIC PAULI PRINCIPLE. W.Krolikowski.

Nuclear Phys. (Internat.), Vol. 23, No. 1, 53-62 (Feb., 1961).

An approach to the problem of classification of elementary fermions proposed previously by the author is summed up. A possible extension of the formalism is pointed out. Some, so far undiscovered fermions ("hyperbaryons") are allowed, in contrast to the primary formalism where only the presently known ones appear (leptons ν, ν', e^-, μ^-, and baryons p, n, Λ, Σ^+, Σ^0, Σ^-, Ξ^0, Ξ^-, provided there are two types of neutrinos ν and ν').

5645 ON THE STRUCTURE OF THE FOUR-POINT FUNCTIONS IN HEISENBERG'S NON-LINEAR SPINOR THEORY. E.Montaldi.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 439-51 (March, 1961).

The vacuum expectation value of a product of four Fermi field operators is investigated within the framework of Heisenberg's nonlinear spinor theory of elementary particles. It is shown that a spectral representation still enjoying all the symmetry properties of the fundamental equation can be constructed. This representation is characterized by only two independent mass spectra, which satisfy various symmetry requirements. Their connection with the mass spectrum of the two-point function is also briefly discussed.

5646 A NOTE ON THE PHENOMENOLOGICAL THEORY OF UNSTABLE PARTICLES. A.Krzywicki and J.Szymanski.

Progr. theor. Phys. (Japan), Vol. 23, No. 2, 376-8 (Feb., 1960).

Some remarks on the interpretation of scattering resonances in terms of unstable particles. R.J.N.Phillips

5647 FORM FACTOR AND STRUCTURE OF PARTICLES. K.Yamamoto.

Progr. theor. Phys. (Japan), Vol. 23, No. 6, 1204-5 (June, 1960).

A definition of an elementary particle is discussed in terms o normal and anomalous thresholds in vertex functions. J.E.Pat

5648 ON THE HYDRODYNAMIC REPRESENTATION OF TH FEYNMANN AND GELL-MANN EQUATION. J.C.Aro

C.R. Acad. Sci. (France), Vol. 251, No. 7, 921-3 (Aug. 17, 1960). In French.

5649 ON A PHYSICAL MODEL OF THE QUANTUM WAVE. J.C.Aron.

C.R. Acad. Sci. (France), Vol. 251, No. 8, 992-4 (Aug. 22, 1960). In French.

Shows that the hydrodynamic representation of the Dirac equation due to Takabayasi (Abstr. 3917 of 1960) can yield solution corresponding to spin waves. J.Hawgo

5650 ON THE RELATION BETWEEN DIFFUSION THEORY AND NON-RELATIVISTIC QUANTUM MECHANICS. J.C.Aron.

C.R. Acad. Sci. (France), Vol. 251, No. 9, 1059-61 (Aug. 29, 1960). In French.

Discussion of the relation between the scattering equation and the quantum-mechanical energy equation for spinless particles shows that, with certain fundamental minimum time and distance units, the quantum potential can be treated as a fictitious potential describing scattering effects, when the statistical approach is used. J.Hawgo

5651 ON THE INTRODUCTION OF STATISTICAL IDEAS IN THE QUANTUM MECHANICS OF PARTICLES WITH SPIN. J.C.Aron.

C.R. Acad. Sci. (France), Vol. 251, No. 10, 1117-18 (Sept. 5, 1960). In French.

Combines the ideas of the two preceding abstracts. J.Hawgo

5652 ON THE HYDRODYNAMIC REPRESENTATION OF THE FEYNMANN AND GELL-MANN EQUATION, AND ON A PHYSICAL MODEL FOR THE QUANTUM WAVE. J.C.Aron.

C.R. Acad. Sci. (France), Vol. 251, No. 17, 1723 (Oct. 24, 1960). In French.

In a correction to previous papers (see preceding abstracts), i is noted that the hydrodynamic representation obtained is valid onl for the non-relativistic case, and then it coincides with that of the Pauli equation. In the relativistic case the representation is that o the Dirac equation. R.A.Newin

5653 REGULARIZATION AND RENORMALIZATION. III. FINITE-PART INTEGRALS. E.R.Caianiello, A.Campolattaro and B.Preziosi.

Nuovo Cimento (Italy), Vol. 18, No. 3, 505-24 (Nov. 1, 1960).

The replacement of ordinary with finite-part integrals, which generalize the definition originally given by Hadamard, was shown previously (Abstr. 1245 of 1960) to yield ipso facto correctly renormalized field equations independently of perturbative techniques, provided due care is taken of the symmetry properties of the theory and some quantitative conditions (closely related to Dyson's heuristic conditions for renormalizability) are satisfied by the theory itself. The present work extends the class of finite-part integrals considered before to cover all instances which may practically occur and several possible prescriptions in configuration space which exhibit the wanted properties are discussed. It appears that some prescriptions are better suited to the study of general questions, such as renormalizability of a theory and deduction of the Lie equations of its renormalization group, while others are more convenient for actual computation, once renormalizability is proved.

5654 "ILLUSORY" STATES AND THE CONDITION FOR CROSSING SYMMETRY. V.D.Kukin and A.R.Frenkin.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 49-51 (July 1, 1960). In Russian.

For abstract, see Abstr. 15277 of 1960. [English translation i Soviet Physics—Doklady (USA), Vol. 5, No. 4, 698-700 (Jan.-Feb., 1961)].

5655 DECAY-MODES OF THE SCHIZON. AN ISOBARIC SPIN ANALYSIS. R.C.Kumar.

Nuovo Cimento (Italy), Vol. 18, No. 5, 856-63 (Dec. 1, 1960).

An isobaric spin analysis of all possible decay-modes of the schizon into two and three strongly interacting particles is made.

5656 ON A GAUGE THEORY OF ELEMENTARY INTERACTIONS. A.Salam and J.C.Ward.

Nuovo Cimento (Italy), Vol. 19, No. 1, 165-70 (Jan. 1, 1961).

A theory of strong as well as weak interactions is proposed using the idea of having only such interactions which arise from generalized gauge transformations.

5657 RENORMALIZATION IN A COMBINED LEE--MACHIDA FIELD THEORY. L.M.Scarfone.

Nuovo Cimento (Italy), Vol. 19, No. 2, 377-81 (Jan. 16, 1961).

The renormalization is re-examined. It is shown that the energy of a new V-ghost found in an earlier investigation (Abstr. 20039 of 1960) is sensitive to the renormalization procedure.

5658 LIE EQUATIONS FOR A LEE MODEL. E.R.Caianiello and S.Okubo.

Nuovo Cimento (Italy), Vol. 19, No. 1, 131-41 (Jan. 1, 1961).

The renormalization in configuration space of a slight generalization of the Lee model is discussed, as an example of general procedures (Abstr. 1245 of 1960) which seem to be applicable also to more general cases than the present one. The replacement of ordinary with finite-part integrals removes consistently all ultraviolet infinities and permits one to write the Lie equations of the renormalization group, the solution of which yields the familiar relations between unrenormalized and renormalized parameters.

5659 PARITY CONSERVATION AND BARYON MASS-DIFFERENCES IN STRONG INTERACTIONS.

N.Dallaporta and L.K.Pandit.

Nuovo Cimento (Italy), Vol. 19, No. 1, 171-8 (Jan. 1, 1960).

In earlier work (Abstr. 17226 of 1960) a scheme of strong interactions was proposed which took account of the baryon mass-differences. It was found that P conservation follows automatically for the whole Lagrangian of this scheme once CP invariance is assumed. It is shown here that this is due to the fact that the Lagrangian can be considered as consisting of different pieces, each of which satisfies certain symmetry conditions of the type formulated by Feinberg and Gürsey (Abstr. 9209 of 1959).

5660 ON SYMMETRIES SHARED BY STRONG AND WEAK INTERACTIONS. A.Pais.

Nuovo Cimento (Italy), Vol. 18, No. 5, 1003-32 (Dec. 1, 1960).

A proposal due to Treiman — global symmetry and non-leptonic decay js-coupling (Abstr. 15264 of 1960) — constitutes the starting point. An inner inconsistency of the theory is noted: $\Sigma^+ \rightarrow n\pi^+$ is forbidden in the approximation employed. This may mean that the basic symmetry assumptions of the theory have to be discarded. On the other hand, there are two possibilities to avoid the inconsistency if need be, while at the same time the predictions on non-leptonic decays are maintained. First possibility: the relative sign ϵ of the $\Sigma\Sigma\pi$ relative to the π--nucleon interaction $= -1$. Second possibility: $\epsilon = +1$. The js-interaction is replaced by a more general one (js and jt coupling). This coupling is subjected to a parity clash condition: js and jt separately are P-conserving, but together they are P-violating. As a consequence both reactions $\Sigma^\pm \rightarrow n\pi^\pm$ are P-conserving in the approximation of global symmetry. The clash condition is realized most simply if in the global symmetry approximation there exists only one type of S-violating current: either V or A. If it is assumed that the same S-violating currents occur in the leptonic as in the non-leptonic decays it then follows that the Ξ-nucleon parity has to be odd. The concept of parity clash is shown to be incompatible with an (overall current) × × (overall current) structure for the totality of the weak interactions. It is incompatible with the idea that a vector boson-quartet carries all weak interactions. This possibility has to stand many tests to survive. In its most natural form it allows the reactions $\Sigma^+ \rightarrow n + e^+ + \nu$, $K^0 \rightarrow \pi^+ + e^- + \bar{\nu}$ to occur. In the simplest version of leptonic decays the charged lepton current itself plays a role analogous to the four vector potential in electromagnetism. All theoretical aspects of S-conserving decays remain unaffected.

5661 IDENTITIES BETWEEN STRONG AND WEAK INTERACTIONS. H.Shimodaira and Y.Takahashi.

Nuovo Cimento (Italy), Vol. 19, No. 3, 537-45 (Feb. 1, 1961).

Models of the axial vector weak interaction proposed by Gell-Mann and Lévy are further investigated. The condition $P^\alpha_{\mu,\mu}(x) = ia\pi^\alpha(x)$, on the weak axial vector, under which the identity $-G_A/G = (\mu_0^2/m_\pi^2)\sqrt{Z_3}(f_1/f_0)d_\pi(0)F_\pi(0)$ holds, is somewhat weakened. It is also demonstrated that the "generalized Ward identity" derived by Bernstein et al. should really be replaced by an equation which is given. The pion decay process into leptons is discussed by introducing the direct coupling between them, in addition to the four-fermion interaction. It is pointed out that the presence of the direct coupling between pion and leptons does not alter the above relation for the ratio G_A/G, its value being independent also of the constant for direct coupling.

5662 GENERALIZED GAUGE INVARIANCE AND STRONG INTERACTIONS. V.Gupta.

Nuovo Cimento (Italy), Vol. 19, No. 3, 586-93 (Feb. 1, 1961).

The principle of generalized gauge invariance is put forward, namely that boson fields and their interactions with the fermion field be introduced only through demanding the invariance of the free fermion Lagrangian under gauge transformations. If one makes renormalizability a further fundamental criterion to be satisfied by the interactions (obtained through generalized gauge transformations) then, meson—baryon strong interactions with only pseudo-scaler coupling can be obtained.

5663 WEAK INTERACTIONS IN THE THEORY OF ELEMENTARY PARTICLES WITH FINITE SPACE. I.S.Shapiro.

Nuclear Phys. (Internat.), Vol. 21, No. 3, 474-91 (Dec. (1), 1960).

A variant of the theory put forth by Coish (Abstr. 9225 of 1959) is considered. Two additional quantum numbers are shown to arise in this theory. The selection rules obeyed by them make it possible to forbid the conversion of baryons into leptons and the neutrinoless decay of muons into electrons. Combined inversion is found to be the only possible law of transformation of wave-functions in the case of space reflections, provided Wigner's transformation law is accepted for time inversions. The spinor field theory proves to be essentially two-component. These results as well as the quantization of electric charge obtained by Coish are a consequence solely of the finiteness of the space—time manifold, ruling out divergences.

5664 PARTIAL SYMMETRIES OF WEAK INTERACTIONS. S.L.Glashow.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 579-88 (Feb., 1961).

Weak and electromagnetic interactions of the leptons are examined under the hypothesis that the weak interactions are mediated by vector bosons. With only an isotopic triplet of leptons coupled to a triplet of vector bosons (two charged decay-intermediaries and the photon) the theory possesses no partial symmetries. Such symmetries may be established if additional vector bosons or additional leptons are introduced. Since the latter possibility yields a theory disagreeing with experiment, the simplest partially symmetric model reproducing the observed electromagnetic and weak interactions of leptons requires the existence of at least four vector-boson fields (including the photon). Corresponding partially-conserved quantities suggest leptonic analogues to the conserved quantities associated with strong interactions: strangeness and isobaric spin.

5665 ON THE ASYMPTOTIC BEHAVIOUR OF CROSS-SECTIONS AT HIGH ENERGIES.

V.B.Berestetsky and I.Ya.Pomeranchuk.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 629-39 (Feb., 1961).

Processes of transformation of two particles into three or four particles in the high-energy region are examined in the pole approximation. In the energy range in which the total elastic scattering cross-section in independent of energy, the cross-section for transformation of two particles into three does not decrease with increasing energy. The cross-section for transformation of two particles into four exhibits a logarithmic growth with the energy. This result leads to the assumption that at very high energies the elastic scattering cross-section tends to zero.

5666 PHENOMENOLOGICAL MODEL OF ELEMENTARY PARTICLE INTERACTIONS.

D.Itô, K.Iwata, S.Furui, K.Fujii and T.Sakuma.

Progr. theor. Phys. (Japan), Vol. 23, No. 6, 1210-11 (June, 1960).

An interaction Lagrangian containing both strong and weak interactions is discussed. J.E.Paton

5667 ASYMPTOTIC BEHAVIOUR OF THE SCATTERING AMPLITUDE AT HIGH ENERGIES. V.N.Gribov.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 249-61 (Jan., 1961).

The asymptotic behaviour of the scattering amplitude is investigated at high energies. It is shown that at high energies the usual diffraction picture of scattering contradicts the unitarity conditions and analytic properties of the scattering amplitude formulated with the help of Mandelstam's representations. In terms of these conditions it is natural to expect that the cross section should decrease faster than $1/\ln E$.

5668 THE ANALYTIC PROPERTIES OF SCATTERING AMPLITUDES IN SIXTH-ORDER PERTURBATION THEORY. G.Wanders.

Nuovo Cimento (Italy), Vol. 18, No. 3, 580-94 (Nov. 1, 1960).

The analyticity properties of the sixth-order contribution to the nucleon—nucleon scattering amplitude, as a function of two complex invariants, are investigated. The regularity domain in the first sheet of these invariants is obtained. This domain turns out to be identical with that implied by Mandelstam's representation.

5669 THE PROBLEM OF PROVING DOUBLE DISPERSION RELATIONS. A.V.Astakhov.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 307-10 (July 11, 1960). In Russian.

For abstract, see Abstr. 15290 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 701-4 (Jan.-Feb., 1961)].

5670 ANOMALOUS THRESHOLDS IN DISPERSION THEORY. I. R.Blankenbecler and Y.Nambu.

Nuovo Cimento (Italy), Vol. 18, No. 3, 595-607 (Nov. 1, 1960).

The form factor of a particle in the so-called anomalous case (loosely bound system) is studied from the viewpoint of: (1) description in terms of a Schrödinger-type wave-function; (2) perturbation theory; and (3) dispersion theory. A prescription is given on how to calculate the absorptive part of a dispersion relation in the correct Riemann sheet.

5671 DISPERSION RELATION AND ANALYTICITY OF A PRODUCTION AMPLITUDE. G.Mohan.

Nuovo Cimento (Italy), Vol. 19, No. 2, 331-43 (Jan. 16, 1961).

A dispersion relation and certain analyticity properties of the amplitude for a process like $n + \pi \to n' + \pi' + \pi''$ is studied on the basis of the Jost—Lehmann—Dyson integral representation of the causal commutator.

5672 POLES IN PRODUCTION CROSS SECTIONS. R.Ascoli.

Nuovo Cimento (Italy), Vol. 18, No. 4, 744-53 (Nov. 16, 1960).

The nature and the position are investigated of the one-particle singularities that are expected in the production cross-section $\partial^2\sigma/\partial w^2\,\partial\Delta^2$, introduced by Chew and Low (Abstr. 7241 of 1959), when considered as a function of the momentum transfer Δ^2. It is found that these singularities are in general in the complex Δ^2 plane. Furthermore, a phenomenon analogous to the "anomalous thresholds" of the scattering processes is found. The phenomenon occurs only with strange particles or nuclei. In some cases it may prevent the application of the extrapolation procedure that has been proposed by Chew and Low to get scattering cross-sections from production experiments.

5673 ANALYTIC PROPERTIES OF PRODUCTION AMPLITUDES AS FUNCTIONS OF TWO MOMENTUM TRANSFERS. R.Ascoli.

Nuovo Cimento (Italy), Vol. 18, No. 4, 754-69 (Nov. 16, 1960).

It is shown that, starting from the Dyson representation, it is possible to prove analytic properties of production amplitudes as functions of two dynamical variables at the same time. As such it is in particular possible to choose two invariant momentum transfers; the remaining variables which are held fixed are only subject to the restriction of determining completely the final momenta and may as well be covariant variables. There is no limitation to the number of final particles; there is only some simplification in the analyticity properties in the case of simple production. The research of the region of analyticity leads to an elegant mathematical problem. The solution of this problem leads to a region of analyticity which is the same in any case and consists of a finite domain in the space of the two complex variables; the domain includes always the physical region.

5674 ANALYTIC PROPERTIES OF BOUND STATES IN POTENTIAL THEORY.

L.Bertocchi, C.Ceolin and M.Tonin.

Nuovo Cimento (Italy), Vol. 18, No. 4, 770-82 (Nov. 16, 1960).

The analytic properties of the vertex functions of a composite particle (deuteron) are analysed in a potential model. The results are compared with the "anomalous" singularities of relativistic perturbation theory.

5675 MANDELSTAM REPRESENTATION FOR THE NON-RELATIVISTIC MANY CHANNEL PROBLEM.

L.Fonda, L.A.Radicati and T.Regge.

Ann. Phys. (USA), Vol. 12, No. 1, 68-85 (Jan., 1961).

The analytic properties are investigated of the transition amplitudes for the collision of two particles each capable of a number of excited states and interacting through a set of generalized Yukawa potentials. Double dispersion relations for each of the amplitudes can be derived only when the reduced mass is the same for all channels and a certain stability condition, which ensures the absence of anomalous thresholds, is satisfied. The Mandelstam representation is then discussed in connection with unitarity and the partial wave expansion is obtained with results similar to the one-channel case.

5676 POTENTIAL MODEL OF DEUTERON PHOTODISINTEGRATION AND MANDELSTAM REPRESENTATION. V.De Alfaro and C.Rossetti.

Nuovo Cimento (Italy), Vol. 18, No. 4, 783-805 (Nov. 16, 1960).

The analytic properties of the fixed angular momentum amplitudes of deuteron photodisintegration are investigated by a potential model. It is shown that these properties agree with those obtained by a Mandelstam representation with anomalous thresholds, as argued by perturbation arguments. This is an argument in favour of the validity of general dispersion techniques in nuclear physics.

5677 BOUND STATES, SHADOW STATES AND MANDELSTAM REPRESENTATION. T.Regge.

Nuovo Cimento (Italy), Vol. 18, No. 5, 947-56 (Dec. 1, 1960).

In a previous paper (Abstr. 4944 of 1960) a technique involving complex angular momenta was used in order to prove the Mandelstam representation for potential scattering. One of the results was that the number of subtractions in the transmitted momentum depends critically on the location of the poles (shadow states) of the scattering matrix as a function of the complex orbital momentum. In this paper the study of the position of the shadow states is carried out in much greater detail. Related inequalities concerning bound states and resonances are also given. The physical interpretation of the shadow states is then discussed.

5678 UNITARITY AND THE MANDELSTAM REPRESENTATION. R.W.Lardner.

Nuovo Cimento (Italy), Vol. 19, No. 1, 77-89 (Jan. 1, 1961).

The three particle terms in the unitarity expansion for a scattering amplitude are examined on the assumption that the relevant production amplitudes satisfy single dispersion relations. It is shown that they can be made to satisfy the Mandelstam representation within the freedom which seems to be allowed by the unitary equation. The proof is extended to the four particle terms.

5679 ON DERIVING EQUATIONS FROM THE MANDELSTAM REPRESENTATION.

A.V.Efremov, V.A.Meshcheryakov, D.V.Shirkov and H.Y.Tzu.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 202-6 (Jan., 1961).

A new recipe is proposed for deriving the integral equations for partial-wave scattering amplitudes on the basis of the dispersion relations at a fixed angle and the unitarity condition. The method is illustrated by applying it in the simplest case of $\pi\pi$-scattering. The results on the πN-scattering are summarized.

5680 PROOF OF THE MANDELSTAM REPRESENTATION FOR EVERY ORDER IN PERTURBATION THEORY.

R.J.Eden.

Phys. Rev. (USA), Vol. 121, No. 5, 1567-76 (March 1, 1961).

It is proved that every term in the perturbation series for a scattering amplitude satisfies the Mandelstam representation when there are no anomalous thresholds. The absence of anomalous thresholds can be investigated from a few low-order diagrams, or reduced diagrams. Under certain conditions it is shown that their absence in fourth order ensures their absence in every order.

5681 NOTES ON THE STATIC PARITY NON-CONSERVING INTERNUCLEON POTENTIAL. G.Barton.
Nuovo Cimento (Italy), Vol. 19, No. 3, 512-27 (Feb. 1, 1961).

If the weak Lagrangian density L consists of self-interacting charged currents, the inclusion into these of a term linear in the pion field leads to a static parity non-conserving internucleon potential V, the general order of magnitude of whose effects no longer depends on the quadratic pion terms needed for the conservation of the vector current. If neutral currents also contribute to L in such a way as to make it an isotopic scalar, the inclusion of linear pion terms has no effect on V, which then remains inappreciable unless the vector current is conserved. The origins of such pion terms are discussed; it emerges incidentally that as a consequence of time reversal invariance, V cannot contain contributions arising from the exchange of a single pion.

5682 GREEN'S FUNCTION IN SOME COVARIANT SOLUBLE PROBLEMS. S.Okubo.
Nuovo Cimento (Italy), Vol. 19, No. 3, 574-85 (Feb. 1, 1961).

Examples of soluble covariant field theory are given, where there is no scattering but where the Green's functions are nontrivial. Exact expressions for the Green's functions are obtained, and in each case they show a peculiar behaviour on the light cone. Some cases exhibit the ghost-like trouble. In one case, it is shown that Lehmann's proof for the spectral representation of the two-body Green's function fails. All examples given here contradict Haag's theorem and the significance of this contradiction is pointed out.

5683 UNITARITY OF THE S-MATRIX AND ANALYTICITY. I. R.Ascoli, A.Bottino and A.Molinari.
Nuovo Cimento (Italy), Vol. 19, No. 4, 687-95 (Feb. 16, 1961).

The problem is solved of finding which analyticity properties of the production amplitudes are required to deduce, by means of the S-matrix unitarity relations, analyticity properties of scattering amplitudes as functions of the momentum transfer. The fundamental feature of the results is that analyticity properties of the production amplitudes are required as functions of two and only two dynamical variables, whichever be the number of produced particles. The general method given does not require th actual calculation of any integral. In particular the authors give for the production amplitudes a condition sufficient for the analyticity within an ellipse of the imaginary part of the scattering amplitude as function of the momentum transfer.

5684 "NON-PHYSICAL" STEPS IN THE PERTURBATION THEORY. O.I.Zav'yalov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 64-7 (July 1, 1960).
In Russian.

For abstract, see Abstr. 15278 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 143-6 (Jan.-Feb., 1961)].

5685 CONTINUATION OF SCATTERING AMPLITUDES AND FORM FACTORS THROUGH TWO-PARTICLE BRANCH LINES. R.Oehme.
Phys. Rev. (USA), Vol. 121, No. 6, 1840-8 (March 15, 1961).

It is shown that scattering amplitudes and form factors have two-particle branch lines which connect two Riemann sheets. For partial wave amplitudes and form factors the dispersive parts and except for square root factors, the absorptive parts are regular functions in the cut energy plane except for isolated poles, physical inelastic cuts and left-hand branch lines. In order to show this it is assumed that, for particles without composite structure, the amplitudes have only singularities in the physical sheet which correspond to absorptive processes. The analytic properties of absorptive parts are used for a general discussion of structure singularities (anomalous thresholds). It is shown that these structure cuts are extensions of left-hand branch lines in the second Riemann sheet. An example is given of a dispersion relation on the Riemann surface in which the integral over the two-particle branch line is eliminated.

5686 A REMARK ON THE THEORY OF FERMIONS WITH HIGHER ORDER DERIVATIVES.
H.M.Fried and J.Plebanski.
Nuovo Cimento (Italy), Vol. 18, No. 5, 884-94 (Dec. 1, 1960).

The problem of negative norms arising in a multifermion theory derived from a single Lagrangian containing derivatives of order higher than the first may be removed by the adoption of a suitable indefinite metric. Interaction S-matrix elements, calculated with the metric operator, are shown to be equivalent to those of the conventional theory.

5687 SCATTERING OF TRANSVERSELY POLARIZED FERMIONS. A.A.Sokolov and M.M.Kolesnikova.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1778-85 (June, 1960).
In Russian.

Elastic scattering of transversely polarized fermions is considered. It is shown that in the ultrarelativistic case scattering of the longitudinally polarized fermions is characterized by a four-dimensional spin pseudovector, while scattering of the transversely polarized ones — by a four-dimensional intrinsic angular momentum tensor. In the latter case interactions proportional to the matrices ρ_1 and ρ_2 leave the scattered fermions transversely polarized; when the interaction energy contains ρ_3 or ρ_4 the longitudinal component may appear after scattering (if the particle has a non-zero rest-mass). [English translation in: Soviet Physics—JETP (USA), Vol. 11, No. 6, 1281-5 (Dec., 1960)].

5688 INTEGRABLE MANY BODY WAVE FUNCTIONS FOR A SYSTEM OF BOSE PARTICLES.
S.F.Edwards and M.A.Naqvi.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 433-46 (Feb., 1961).

It is shown that, by means of a parametric representation, a variational calculation for a system of Bose particles can be carried through using explicit trail wave-functions which describe a state with a fixed number of particles and include pair correlations. For the ground state the results of previous work are obtained as the first term in a steepest descent calculation. An effective Schrödinger equation is obtained for the relative motion of two particles. The application of the method to excited states is discussed; in particular for the case of a vortex line in the system it is shown that the method leads to an analysis which is similar to that for the ground state and could be carried through in the same way.

5689 ENERGY GAP IN THE SPECTRUM OF FREE QUASI-PARTICLES IN NUCLEAR MATTER.
G.Fano and A.Tomasini.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1247-57 (Dec. 16, 1960).

A sufficient condition is given for the existence of an energy gap in the spectrum of free quasi-particles in nuclear matter, assuming a finite repulsive potential inside the core.

5690 FIELD THEORIES WITH "SUPERCONDUCTOR" SOLUTIONS. J.Goldstone.
Nuovo Cimento (Italy), Vol. 19, No. 1, 154-64 (Jan. 1, 1961).

The conditions for the existence of non-perturbative type "superconductor" solutions of field theories are examined. A non-covariant canonical transformation method is used to find such solutions for a theory of a fermion interacting with a pseudoscalar boson. A covariant renormalizable method using Feynman integrals is then given. A "superconductor" solution is found whenever in the normal perturbative-type solution the boson mass squared is negative and the coupling constants satisfy certain inequalities. The symmetry properties of such solutions are examined with the aid of a simple model of self-interacting boson fields. The solutions have lower symmetry than the Lagrangian, and contain mass zero bosons.

5691 COMPOUND PAIR STATES IN IMPERFECT FERMI GASES. H.Kümmel.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 177-83 (Jan., 1961).

The Bethe—Goldstone equation is replaced by a rigorous nonlinear integro-differential equation determining the two-particle correlations and the interaction energy. This nonlinear equation is solved for vanishing total momentum and separable potential. The hole—hole and particle—hole interactions as well as the three- and four-particle clusters are neglected. There are no singularities in this more rigorous equation. For those values of the two-particle energy for which singularities occur, if one neglects the quadratic terms, the solutions are of "compound type", i.e. the localized part has a large (but finite) amplitude compared with the unperturbed plane wave.

5692 THE MOMENT OF INERTIA OF LARGE SUPERFLUID FERMION SYSTEMS. R.E.Prange.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 283-300 (Jan., 1961).

The moment of inertia of a superfluid system is calculated according to the Bardeen–Copper–Schrieffer–Bogolyiubov model. In order to obtain sensible results, it is necessary to include not only the independent pair excitations, but also the phonon excitations. A method of calculating the effects of these excitations is developed, which exhibits the fact that many of the excitations cannot be easily produced, since there is an "energy gap" against their formation. Other excitations are, however, easily produced. These excitations are characteristic of a macroscopic irrotational flow, and may be described loosely as a centre-of-mass motion of the "bound" pairs of the Bardeen–Cooper–Schrieffer–Bogolyiubov theory. Thus the irrotational flow moment of inertia is predicted. This result does not apply to finite systems in which the shell spacing is significantly large. Corrections to the formula of Belyaev for finite nuclei are suggested. Finally, some remarks are made on the origin of the cranking model.

5693 NOTES ON THE THEORY OF VIBRATIONAL STATES OF SYSTEMS OF FERMIONS. I. J.Sawicki.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 285-95 (Feb., 1961).

The system of nonlinear equations for the components of the single-particle density matrix operator is discussed, for both infinite and finite systems of fermions interacting through a two-body "residual" interaction. The Hartree–Fock factorization and linearization of that system of equations for the density fluctuations can be performed. Hartree–Fock exchange terms and, particularly, deviations from the random phase approximation, are discussed. The importance of these deviations is illustrated by the example of the quadrupole vibrations of a closed spherical nuclear subshell. An apparent ambiguity in the linearization procedure is discussed and the importance of the nonlinearity of equations is stressed.

5694 ON THE "NEW TAMM–DANCOFF" APPROXIMATION TREATMENT OF THE SUPERCONDUCTIVITY HAMILTONIAN. K.Yamazaki.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 139-43 (Feb., 1961).

The "new Tamm–Dancoff" approximation method in the same form as used in Heisenberg's theory of elementary particles is applied to Bardeen's reduced Hamiltonian for the theory of superconductivity. In the limit of infinite volume exactly the same energy gap as found by Bardeen and Bogolyubov is obtained.

5695 GROUP THEORY OF HARMONIC OSCILLATORS. II. THE INTEGRALS OF MOTION FOR THE QUADRUPOLE-QUADRUPOLE INTERACTION.
V.Bargmann and M.Moshinsky.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 177-99 (Feb., 1961).

For Pt I, see Abstr. 20082 of 1960. Reports calculation of 3N integrals of motion associated with a system of N particles moving in a common harmonic oscillator potential and having a quadrupole–quadrupole interaction. The eigenvalues of these 3N integrals of motion are obtained by applying the corresponding operators to the reduced canonical wave-function defined in a previous paper. The reduced canonical wave-function is constructed explicitly and it is shown to give a basis for all the irreducible representations of the three-dimensional unitary unimodular group. One of the integrals of motion obtained is essentially the quadrupole moment projected along the direction of the angular momentum and its eigenvalues are discussed in detail.

ELEMENTARY PARTICLES

5696 RECENT PROGRESS IN PARTICLE PHYSICS. I. M.Hoyaux and P.Gans.
ACEC Rev. (Belgium), 1960, No. 3, 2-22. In French.

Review for the non-specialist, with photographs of apparatus at CERN, Geneva.

5697 ON THE COULOMB SCATTERING BY A SPHERICAL CHARGE DISTRIBUTION. L.Favella and E.Predazzi.
Nuovo Cimento (Italy), Vol. 18, No. 3, 570-9 (Nov. 1, 1960).

An analytic expression for the total scattering amplitude of charged particles by a static charge distribution with spherical symmetry, is derived. The corresponding potential is supposed to be an arbitrary superposition of Laguerre functions. The evaluation has been performed using the Coulomb point-charge waves as an approximation of first order, and iterating one time for taking into account the charge's extension.

5698 SOME REMARKS ON THE PHASE-SHIFT ANALYSIS WITH D-WAVES FOR TRACK-CHAMBER HISTOGRAMS. I.Derado and R.Van de Walle.
Nuovo Cimento (Italy), Vol. 19, No. 4, 777-86 (Feb. 16, 1961).

A possible new method of phase-shift analysis of track-chambe histograms is discussed. Methods available for correcting the angular distribution for Coulomb scattering and for calculating the phase-shift errors are considered. As an example of application a re-analysis is given of the π^+-scattering experiment at 310 MeV of Foote et al. (Abstr. 5590 of 1960).

5699 WIGNER CONDITION AND LOW ENERGY SCATTERING. P.Menotti and Y.Tomozawa.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 506-12 (March, 1961).

Relations between the interaction range, effective range and scattering length for s- and p-waves are derived by using Wigner's inequalities for the momentum derivative of the scattering phase shift. Applications to π–N and n–p scattering are given. In particular it is shown that the obtained value ($R \geq 0.68\ \hbar/\mu c$) for lower limit of the interaction range for s-wave ($T = \frac{3}{2}$) in π–N scattering might support the existence of π–π interaction.

Photons

5700 THE REACTION $\gamma + \gamma \to \nu + \bar{\nu}$. M.Gell-Mann.
Phys. Rev. Letters (USA), Vol. 6, No. 2, 70-1 (Jan. 15, 1961).

It is shown that, for a local coupling, this reaction is forbidde It is also shown how the reaction rate for the process $\gamma + \gamma \to \nu + \bar{\nu} + \gamma$ can be calculated. E.J.Squir

5701 SPECTRAL DISTRIBUTION OF SCATTERED GAMMA-RADIATION. N.Dubinskaya and U.Ulmanis.
Latv. PSR Zinat. Akad. Vestis (USSR), No. 5 (154), 61-6 (1960). In Russian.

The dependence of the spectra of scattered γ-rays on the geometry and atomic number of the scatterers and on the angles of incidence and reflection was determined experimentally. Two peaks were observed in the intensity versus energy curve. The behaviour of these can be explained in terms of single scattering events, the energy of which does not depend on the thickness or atomic number of the scatterers, and a small number of multiple scatterings, the energy and intensity of which usually changes with both of these parameters. E.A.Sanderson

5702 PROTON COMPTON EFFECT. G.Bernardini, A.O.Hanson, A.C.Odian, T.Yamagata, L.B.Auerbach and I.Filosofo.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1203-36 (Dec. 16, 1960).

The elastic scattering of photons by protons was measured for 100 MeV to 290 MeV photons at 90° c.m.s. and 139° c.m.s. scattering angles. The expected large increase in cross-section is observed at energies approaching that of $(\frac{3}{2}, \frac{3}{2})$ pion–nucleon resonance. The scattering can be qualitatively explained by the ordinary Thomson amplitude combined with that of the $(\frac{3}{2}, \frac{3}{2})$ resonance. A more detailed examination of the cross-section in the region just above the photo-meson threshold has shown that it is sensitive to the π^0 photon coupling. From the experimental data, one may conclude that the π^0 mean life should be between 10^{-16} and 10^{-18} sec.

5703 ANGULAR AND ENERGY DISTRIBUTIONS OF γ- RAYS SCATTERED IN IRON AND LEAD.
Yu.A.Kazanskii, S.P.Belov and E.S.Matusevich.
Atomnaya Energiya (USSR), Vol. 5, 457 (1958). In Russian.

Measurements were made of the angular and energy distributions for γ-rays of energy 0.411 MeV (Au^{138}), 1.17 MeV and 1.33 MeV (Co^{60}) in semi-infinite geometry in lead and iron. The results are compared with calculations of Goldstein and Wilkins, fair agreement being obtained. The angular distribution of the scattered intensity does not depend markedly on the thickness of the scatterer. [English translation in: Reactor Science (GB), Vol. 10, No. 3-4, 185-7 (Sept., 1959)]. R.H.Thomas

5704 STUDENT EXPERIMENT ON THE ATTENUATION OF GAMMA RADIATION. H.W.Taylor and G.N.Whyte.
Amer. J. Phys., Vol. 29, No. 5, 315-18 (May, 1961).

An experiment employing only simple apparatus reveals aspects of the attenuation of gamma radiation in matter that are frequently ignored. The student is introduced to the exponential attenuation of gamma rays under narrow-beam conditions, the importance of scattered radiation in the more commonly encountered broad-beam conditions, and the concept of buildup factor.

5705 THE ABSORPTION, IN WATER, OF THE GAMMA-RADIATION FROM POINT AND VOLUME SOURCES.
G.V.Gorshkov and V.M.Kodyukov.
Atomnaya Energiya (USSR), Vol. 5, No. 1, 71-2 (1958). In Russian. English translation in: Reactor Science (GB), Vol. 10, No. 1-2, 65-7 (July, 1959).

The results are given of an experimental study of the attenuation in water of the gamma-radiation from volume and point sources of Na^{24} and Au^{198}. The volume source was provided by an aqueous solution in a tank in the shape of a truncated cone (base diameter 1.5 m and height 1 m). It is shown that for the point sources the experimental results differ significantly from those given by Fano (Abstr. 5664 of 1954), the difference becoming more marked as the gamma-ray energy is decreased. The character of the attenuation curve depends on the source shape and on the spectral composition of the gamma-radiation. The build-up factor is less for a plane source than it is for a volume or point source. The difference increases as the gamma-ray energy decreases and also with increasing absorber thickness. C.F.Barnaby

5706 ISOTHERMAL GAMMA CALORIMETER.
A.P.Komar and Z.Kovarzh.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 1, 116-24 (Jan., 1961). In Russian.

A calorimeter is described to be used for measuring the intensity of γ-ray emission from betatrons and similar sources of radiation. Liquid nitrogen is used as calorimetric substance and the amount of absorbed heat is derived from the rate of evaporation. The calorimeter proper is shielded by two layers of liquid nitrogen. Radiation is admitted through a copper foil and absorbed in a lead block. The saturation pressure in the heat shield is automatically controlled and the rate of evaporation is automatically recorded. The calorimeter is calibrated by electric heating. In application to γ-emitters several corrections are applied. An account is given of measurements on a 85 MeV synchrotron. [English translation in: Soviet Physics--Technical Physics (USA)]. R.Eisenschitz

5707 A COMPARISON OF TWO FLUOROMETERS DESIGNED TO MEASURE THE RADIATION-INDUCED FLUORESCENCE OF SILVER-ACTIVATED GLASS RODS.
N.F.Barr, M.Stark and J.S.Laughlin.
Radiology (USA), Vol. 76, No. 1, 113-15 (Jan., 1961).

The instrument adapted by the authors, though of only 1/100 the sensitivity of the other, had better linearity above 10 000 rads for γ-rays and 500 rads for X-rays, and was also more convenient to use. S.T.Henderson

BREMSSTRAHLUNG SPECTRUM OF THE 1000 MeV ELECTRONSYNCHROTRON AT FRASCATI. See Abstr. 5524

5708 THE ACCURACY OF ABSOLUTE MEASUREMENTS OF THE INTENSITY OF A BEAM OF [HIGH-ENERGY] PHOTONS FROM A SYNCHROTRON TARGET BY MEANS OF IONIZATION CHAMBERS. I.N.Usova.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 17-19 (Nov.-Dec.). In Russian.

It is shown that it is necessary to take into account the presence of long-range δ-electrons which carry away a portion of the energy lost by secondary electrons in the operating volume of the chamber. Equations permitting a sufficiently accurate evaluation of this effect are derived. Calculations determining the bremsstrahlung of the FIAN synchrotron, which has a maximum energy of 260 MeV, showed that, by taking into account the presence of long-range δ-electrons, the absolute sensitivity of the thick-walled graphite chamber ($T = 4.5$ cm) is changed by 2%, and the absolute intensity, measured by means of a thin-walled chamber according to the method of pair differences, is increased by 12%. [English translation in: Instrum. exper. Tech. (USA), No. 6, 876-9 (Nov.-Dec., 1959; publ. Sept., 1960)].

5709 A QUANTOMETER FOR MEASURING THE ENERGY FLUX OF BREMSSTRAHLUNG FROM BETRATRONS AND SYNCHROTRONS AND ITS INVESTIGATION FOR $E_{\gamma max} < 100$ MeV. A.P.Komar and S.P.Kruglov.
Zh. tekh. Fiz. (USSR), Vol. 30, No. 11, 1369-80 (Nov., 1960). In Russian.

The theory of the bremsstrahlung quantometer is set out in more detail than hitherto published. This instrument automatically integrates the current—penetration curve governing the interaction of bremsstrahlung with matter, and with simple marginal corrections gives the total energy flux. The quantometer constant is shown (theoretically and experimentally) to change only by a few per cent when the maximum energy accepted is reduced from 300 MeV to 85 MeV. [English translation in: Soviet Physics — Technical Physics (USA), Vol. 5, No. 11, 1299-1310 (May, 1961)]. A.E.I. Research Laboratory

ČERENKOV RADIATION IN THE ATMOSPHERE. See Abstr. 5798

X-rays

5710 QUANTITY AND QUALITY OF SCATTERED X RAYS. J.H.Martin and G.M.Muller.
Brit. J. Radiol., Vol. 34, 227-35 (April, 1961).

Measurements were made of the amount and quality of radiation scattered from materials of different atomic numbers. At all energies of the primary X-ray beam used, low atomic-number materials scatter the greatest quantity of radiation; the differences in the normal deep therapy range are large. The quality of the radiation scattered shows a maximum for scatterers of medium atomic number in this energy range and a steady increase with atomic number at the highest energy used.

5711 THE STATISTICAL ERROR IN X-RAY ABSORPTION MEASUREMENTS. B.Nordfors.
Ark. Fys. (Sweden), Vol. 18, Paper 3, 37-47 (1960).

The statistical error in the determination of X-ray absorption coefficients is studied for the case of counter registration. Optimum conditions are found for the absorber thickness and for the time distribution between measuring I_0 and I. The influence of background radiation is discussed, and a table giving the optimum conditions for different backgrounds is appended.

5712 COMPTON DOSIMETER FOR MEASUREMENT OF PENETRATING X-RAYS AND GAMMA RAYS.
B.Gross.
Radiation Research (USA), Vol. 14, No. 2, 117-30 (Feb., 1961).

A unidirectional beam of photons in an insulator produces a "directional" current in the absence of an external electric field. This allows the construction of a γ-ray battery. In this battery a central electrode system measures the electrical current produced by the Compton electrons in an insulator placed on top of the electrode and also absorbs the γ-ray beam after its passage through the insulator-scatterer. The battery can operate in short circuit or in open circuit. Its output is proportional to the radiation dose. Backscattering and interface effects can be minimized by the use of a "metallized" dielectric in connection with the central electrode.

PHOTON-COUNTING SPECTROMETER FOR ATTENUATION MEASUREMENTS IN THE SOFT X-RAY REGION. See Abstr. 4687

Electrons

5713 AN INSTRUMENT FOR THE AUTOMATIC OPERATION OF A MAGNETIC SPECTROMETER.
B.P.Peregud and K.B.Abramova.
Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 12-17 (March-April). In Russian.

An instrument is described which automatically counts the particles which pass through the detector of a β-spectrometer in a given time interval for each of 25 values of the energy of the particle. The counting time at each point can be adjusted within the limits 1 sec to 25 min. The interval between two neighbouring energy values can also be varied within wide limits which depend on the construction of the spectrometer. Registration of the number of particles is carried out by 25 mechanical recorders. With minor alterations, the instrument can be used for the control of a luminescense spectrometer. [English translation in: Instrum. exper. Tech. (USA), No. 2, 184-90 (March-April, 1958; publ. April, 1959)].

5714 DIFFERENCE IN THE MULTIPLE SCATTERING OF ELECTRONS AND POSITRONS.

B.P.Nigam and V.S.Mathur.
Phys. Rev. (USA), Vol. 121, No. 6, 1577-80 (March 15, 1961).

The difference in the multiple scattering of electrons and positrons is calculated on the basis of the work of Nigam, Sundaresan and Wu (Abstr. 13016 of 1959). The results are compared with the experimental work of Henderson and Scott (Abstr. 4455 of 1957) and are found to be in good agreement.

5715 ANGULAR CORRELATION OF ANNIHILATION RADIATION IN SILICA AND AQUEOUS SOLUTIONS.

P.Colombino, I.Degregori, L.Mayrone, L.Trossi and S.DeBenedetti.
Nuovo Cimento (Italy), Vol. 18, No. 4, 632-43 (Nov. 16, 1960).

The experimental apparatus used to study the angular distribution of γ-rays from positron annihilation is described. The results of measurements carried out on various forms of silica and on aqueous solutions of several salts are discussed.

5716 NUMERICAL EVALUATION OF THE PSEUDO-TRIDENTS PRODUCTION CROSS-SECTION.

C.Piron, M.Gailloud, P.Rosselet and M.Biasutti.
Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 945-52 (1960).

The number of apparent tridents produced by bremsstrahlung was calculated for arbitrary experimental conditions and $E/mc^2 < 10^5$.

Nucleons

5717 THEORY OF LOW ENERGY NUCLEON—NUCLEON SCATTERING. II. HIGH WAVES.

D.Amati, E.Leader and B.Vitale.
Nuovo Cimento (Italy), Vol. 18, No. 3, 409-29 (Nov. 1, 1960).

The theory developed in Pt I (Abstr. 15341 of 1960) is applied to the special case of high waves. The distinction between "high" and "low" waves is discussed, and it is hoped that the formula given will yield a valid representation of the nucleon—nucleon partial wave amplitudes for values of the orbital momentum $l \geq 2$. For these high waves the cut in the energy plane due to three pion or more massive intermediate states is supposed to give a negligible contribution. In this case the representation given in Pt I reduces to a set of explicit formula for the partial wave amplitudes. These formulae contain explicitly the effect of the Born term and rescattering corrections in pion nucleon scattering as well as the effect of a possible pion—pion interaction.

5718 THEORY OF LOW ENERGY NUCLEON—NUCLEON SCATTERING. III. PARTIAL WAVE INTEGRAL EQUATIONS FOR LOW ORBITAL MOMENTUM AMPLITUDES.

D.Amati, E.Leader and B.Vitale.
Nuovo Cimento (Italy), Vol. 18, No. 3, 458-65 (Nov. 1, 1960).

The theory developed in Pt I and II is applied to the low orbital momentum scattering amplitudes. Integral equations for these amplitudes are constructed, and the entire two-meson contribution to the left hand cut is explicitly given in terms of the effect of the Born term and 3, 3 resonance in pion—nucleon scattering and a possible π—π interaction. The contributions to the cut from higher mass intermediate states are assumed to be given by a low order polynomial in the energy, whose coefficients will appear as phenomenological constants in the theory. The integral equations are exactly of the form treated recently by Noyes and the present work may be regarded as a specification of the left hand cut discontinuity to be used in those equations, whose solutions should give the energy variation of the low partial waves.

5719 THE TWO MESON APPROXIMATION FOR THE REAL NUCLEON. G.Eder.

Nuovo Cimento (Italy), Vol. 18, No. 3, 430-42 (Nov. 1, 1960).

The method of momenta proposed by Halpern (Abstr. 9548 of 1957) is applied to the description of the real nucleon state in the two meson approximation. The static model of Chew and Low for a extended source is used. It seems possible to get a weakly coupled model which gives a good value of f^2 and which fits rather well the sum rules for the pion—nucleon scattering amplitudes.

5720 TWO-PION ANNIHILATION OF A $N-\bar{N}$ PAIR. R.P.Saxena.

Nuclear Phys. (Internat.), Vol. 23, No. 1, 158-63 (Feb., 1961).

The problem of double-pion annihilation of a nucleon—antinucle pair is investigated with the help of new Tamm—Dancoff techniques It is shown that the empirical selection rules given earlier by Bethe and Hamilton follow automatically from the present formalism. Further, the annihilation cross-sections for various specific processes are calculated and a limited effort is made to compare these results with those of the experiments.

Protons

5721 THEORETICAL MAGNETIC MOMENTS OF PROTON AND NEUTRON. K.M.Guggenheimer.

Nature (GB), Vol. 188, 1014-16 (Dec. 17, 1960).

The equation $E = 38.46\,[l(l+1) + s(s+1)]$ MeV is shown to be relevant not only in calculation of the elementary heavy fermion masses, but also in calculation of the internal excitation energies of the free proton and of the magnetic moments of the proton and the neutron. The theoretical values for μ_n and μ_p are in good agre ment with the empirical values. This permits the inference that th pion in a nucleon is not virtually created but permanently present i a well-defined state. Reasons are given for the exceptional stabilit of the proton. F.Herbu

5722 RESULTS OF CROSS-SECTION MEASUREMENTS FOR THE REACTION $p + D \rightarrow He^3 + \pi^0$ AT 600 MeV.

M.Ferro-Luzzi and G.Pizzella.
Ricerca sci. (Italy), Vol. 30, No. 3, 400-4 (March, 1960). In Itali

The reaction $p + D \rightarrow He^3 + \pi^0$ at 600 MeV was investigated using nuclear emulsions and its cross-section for various angles was measured.

5723 ROLE OF THE PERIPHERAL INTERACTION IN PROTON—PROTON COLLISIONS. F.Selleri.

Phys. Rev. Letters (USA), Vol. 6, No. 2, 64-6 (Jan. 15, 1961).

The cross-section, as a function of final neutron energy, for the reaction $p + p \rightarrow p + n + \pi$ is calculated on the assumption that it is dominated by the exchange of a pion. The contribution of π^0 exchange is neglected since isobaric spin arguments show that it is only about one-ninth that of π^+ exchange. The pion—nucleon vertex and the pion propagator are taken in lowest order, and the pion—nucleon scattering function is approximated by its value when all particles are on their mass shells. The calculated distribution agrees well with experiments at 970 MeV, and the calculated total cross-section is 12 mb compared to 16 mb found experimentally.

E.J.Squire

5724 PROTON—PROTON DIFFERENTIAL CROSS SECTION AT 1 GeV. J.D.Dowell, W.R.Frisken, G.Martelli, B.Musgrave, H.B.van der Raay and R.Rubinstein.

Nuovo Cimento (Italy), Vol. 18, No. 4, 818-19 (Nov. 16, 1960).

The p—p differential cross-section at (1010 ± 20) MeV was measured to an accuracy of from 2-5% at 10 angles between 18° 30' and 90° centre-of-mass. For normalization the total cross-section (Abstr. 8586 of 1959) was used, it being assumed that the forward scattering amplitude is purely imaginary. A.Ashmor

5725 SPIN CORRELATION MEASUREMENTS IN p—p SCATTERING AT 382 AND 320 MeV.

J.V.Allaby, A.Ashmore, A.N.Diddens, J.Eades, G.B.Huxtable and K.Skarsvåg.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 234-56 (Feb., 1961).

An account is given of the measurement of the spin correlatio coefficients C_{nn} and C_{KP} in p—p scattering at 90° centre-of-mass scattering angle. C_{nn} was measured at 382 and 320 MeV, C_{KP} at

382 MeV. The method of calibrating the polarization analysers is described and details given of the corrections for random coincidences and for the geometrical contribution to asymmetry. The experimental results were:

$$C_{nn} \quad 382\text{ MeV}, \quad +0.41 \pm 0.09,$$
$$C_{nn} \quad 320\text{ MeV}, \quad +0.77 \pm 0.11,$$
$$C_{KP} \quad 382\text{ MeV}, \quad +0.63 \pm 0.10.$$

The results are discussed in relation to the 310 MeV phase shift analyses and the potential models of Gammel an Thaler, and Bryan.

5726 THE POLARIZATION OF THE PROTON FROM THE PROCESS $\gamma + p \to p + \pi^0$ IN THE REGION OF THE HIGHER RESONANCES. R.Querzoli, G.Salvini and A.Silverman.
Nuovo Cimento (Italy), Vol. 19, No. 1, 53-76 (Jan. 1, 1961).

The polarization of the recoil proton in the photoproduction process $\gamma + p \to p + \pi^0$ was measured with the beam of the Frascati electrosynchrotron at an angle of 90° in the c.m. system, in the energy interval (500-900) MeV. A counter technique was used, and the polarization of the proton was revealed by the left to right asymmetry in the elastic scattering of the protons in a carbon target. A definite polarization is found, always of the same sign and equal to -0.4 ± 0.14, -0.63 ± 0.23, -0.6 ± 0.25, -0.57 ± 0.12, -0.38 ± 0.09, -0.5 ± 0.17, -0.5 ± 0.22 at the γ-ray energies of 560, 610, 650, 700, 750, 800, 850 MeV respectively. The discussion of these experimental results, together with the data of angular distributions, leads to the conclusion that they are in agreement with the hypothesis that the second resonance is a transition $(E_1, d^{3/2})$ and the third one is a transition $(E_2, f^{5/2})$.

5727 REACTION $\bar{p} + p \to \bar{Y} + Y$.
J.Button, P.Eberhard, G.R.Kalbfleisch, J.E.Lannutti, G.R.Lynch, B.C.Maglić, M.L.Stevenson and N.H.Xuong.
Phys. Rev. (USA), Vol. 121, No. 6, 1788-97 (March 15, 1961).

The study of the interaction $\bar{p} + p \to \bar{\Lambda} + \Lambda$, performed with a 72 in. hydrogen bubble chamber, yielded 11 of these events in a total of 21 100 antiproton interactions at 1.61 BeV/c. The cross-section for $\bar{\Lambda} + \Lambda$ production was estimated as 57 ± 18 μb. Eight of the 11 $\bar{\Lambda}$-particles went forward in the c.m. system. At the higher momentum of 1.99 BeV/c, one single-V and one double-V event fitting $\bar{\Lambda} + \Lambda$ production unambiguously and one single-V and one double-V event fitting $\bar{\Sigma}^0 + \Lambda$ or $\Sigma^0 + \bar{\Lambda}$ were observed in 4920 antiproton interactions. These events yields a $\bar{\Lambda} - \Lambda$ production cross-section of 55 ± 40 μb; this value is consistent with that predicted by the ratio of phase space on the basis of the 1.61 BeV/c data. No charged $\bar{\Sigma}$ events were observed at the higher momentum. Three stages of particle separation utilizing velocity-selecting spectrometers were employed. At the lower momentum, background pions were one-third as numerous as antiprotons at the bubble chamber and the flux of antiprotons was about one per picture. At the higher momentum, the background pion to antiproton ratio was 1.8, and the flux of antiprotons was one every 6 pulses. Delta rays on incident interacting tracks were used to determine beam composition.

5728 ANTIPROTON ANNIHILATIONS IN COMPLEX NUCLEI.
A.G.Ekspong, Å.Frisk, S.Nilsson and B.E.Ronne.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 353-409 (Feb., 1961).

An investigation of 356 antiproton annihilations in nuclear emulsion is reported. The results are generally analysed to yield information on primary processes, assumed to be annihilations with single protons or neutrons into a number of pions with or without a K-meson pair. The average pion multiplicity is 4.68 ± 0.12 for annihilations at rest, and 5.11 ± 0.12 for annihilations in flight (the antiproton energy being on the average 166 MeV). This increase of 0.4 ± 0.2 pions is to be compared with an expected average increase of 0.1 pion. The pion energy distributions are given with mean values of 391 ± 10 MeV total energy (at rest) and 390 ± 9 MeV (in flight). Emission of K-meson pairs is found to take place in 3 ± 2% of the annihilation reactions. The average number of pions emitted together with K-mesons is 2.2 ± 0.5. The correction for K-meson pairs unobservable in usual emulsion experiments is computed. The result is that about 40% of the K-meson pairs are undetectable, which means that the correction for detection efficiency is larger than previously assumed. A recalculation of all published data, using emulsion detectors, results in a world average of 5.0 ± 1.1% of the annihilations with K-meson pairs for annihilations at rest and in flight (antiproton energy below 250 MeV). The annihilation probability at rest with neutrons is found to be less than that with protons on the basis of a determination of the number of stars with an odd number of charged pions relative to that with an even number. The ratio odd/even is 0.73 ± 0.09. The reabsorption probability of the pions in complex emulsion nuclei is determined. It is found that 18% of the pions are absorbed on the average (at rest) and 32% (in flight). The difference is understood as a result of the movement of the centre-of-momentum and the penetration of the antiprotons into the nuclei for the cases produced in flight. Comparison of the reported experimental results with the predictions of various theories is carried out. For the pion production, however, no decision in favour of a particular theoretical model can be made. As regards the production of K-mesons, all theories fail to predict the experimentally found production frequency. The world data on antiproton annihilations are collected, re-analysed and discussed.

Neutrons

5729 THEORETICAL THERMAL NEUTRON FLUX SHAPE IN A SOLID CYLINDRICAL ROD. R.Bonalumi.
Energia nucleare (Italy), Vol. 8, No. 1, 71-2 (Jan., 1961).

5730 SCATTERING OF SLOW NEUTRONS BY NH_3 MOLECULES. I. SCATTERING BY GASEOUS NH_3.
J.A.Janik, J.Janik and A.Wanic.
Physica (Netherlands), Vol. 26, No. 6, 449-52 (June, 1960).

The scattering cross-section versus neutron energy was measured for gaseous NH_3. Agreement with the theory of Krieger and Nelkin was obtained.

5731 NEUTRON POLARIZATION BY COULOMB SCATTERING B.Margolis.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 498-9 (Feb., 1961).

The polarization of neutrons by Coulomb scattering is examined in the low-energy region ($kR \ll 1$) at energies corresponding to a Breit–Wigner s-wave resonance. It is found that one has virtually 100% polarization at small angles.

5732 THERMAL DIFFUSION LENGTH MEASUREMENTS ON GRAPHITE IMPREGNATED BY DIPHENYL.
R.Bonalumi, S.Bruschetti, C.Bruschi and G.B.Zorzoli.
Energia nucleare (Italy), Vol. 7, No. 9, 611-29 (Sept., 1960).

The possibility of producing a moderating medium with a C/H ratio close to 10 by impregnating graphite with diphenyl was investigated. The impregnated graphite production facility is described, along with a survey of the nuclear properties of the produced material. Thermal diffusion length measurements on such a moderator are illustrated and the experimental results are discussed.

5733 MEASUREMENT OF THE TEMPERATURE DEPENDENCE OF THE DIFFUSION OF NEUTRONS IN WATER AND DIPHYL BY THE PULSE METHOD. M.Küchle.
Nukleonik (Germany), Vol. 2, No. 4, 131-9 (June, 1960). In German.

The absorption cross-section, diffusion, and diffusion cooling constants were measured for thermal neutrons in water (at 22° to 80°C) and diphyl (at 20° to 180°C), using a pulsed neutron source, a BF_3-counter and a 25-channel analyser. The sources of error in this method and the corrections for them are discussed. The results obtained are compared with the measurements and theoretical calculations of other authors. D.H.Lord

5734 IMPROVEMENTS IN THE FAST NEUTRON TIME OF FLIGHT TECHNIQUE USING PULSE SHAPE DISCRIMINATION IN AN ORGANIC PHOSPHOR.
R.Batchelor, W.B.Gilboy, A.D.Purnell and J.H.Towle.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 146-50 (Aug., 1960).

A very simple pulse shape discriminator based upon the method suggested by Owen (1958) has been developed for the scintillation detector of a neutron time-of-flight apparatus. Almost complete cancellation of γ-ray pulses is obtained with the circuit adjusted to pass neutrons of energies greater than 0.4 MeV. By discriminating against γ-rays with the detector placed inside a large water shield, the random background has been reduced by a large factor. The improvement obtained is illustrated with an inelastic neutron spectrum taken with iron at 4 MeV incident neutron energy. In this case the background reduction factor is between 5 and 10.

5735 METHOD FOR THE ABSOLUTE MEASUREMENT OF THERMAL NEUTRON FLUX.

H.Hulubei, C.Beşliu, A.Berinde, M.Ivascu and N.Martalogu.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 223-8 (1959). In Roumanian.

Loaded NIKFI nuclear emulsions are used, the concentrations of boron and lithium atoms being known within 1%; several portions are exposed to the flux for different times. By plotting the density of tracks in the surface due to boron as a function of exposure, the absolute value of the thermal neutron flux is obtained from the slope. The error of the method is ~3%. A procedure is also given for controlling the accuracy of the measurements, as well as a new method of scanning. A.Ashmore

5736 NEUTRON FLUX MEASUREMENTS FROM 100 keV TO 4 MeV WITH A MODIFIED LONG COUNTER.

E.Tochilin and R.V.Alves.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 225-9 (Aug., 1960).

Long counter response to neutrons from a 2 MeV positive ion accelerator was investigated with three instruments which were identical except for the thermal shields within their outer cores. These shields consisted of B_2O_3, Cd, and polyethylene sleeves. For neutron energies ranging from 0.1 to 4.MeV no differences in relative response were observed for the three counters. Measurements made with indium strips placed along the axis of the counter in place of the conventional BF_3 detector showed that the foil technique could significantly extend the intensity range of the counter at no sacrifice in energy response.

5737 CALCULATED SHAPES FOR NEUTRON BURSTS PRODUCED BY PHASED CHOPPER VELOCITY SELECTORS.

N.H.Tolk and R.M.Brugger.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 203-10 (Aug., 1960).

The burst shapes and transmission probabilities for neutrons passing through a phased chopper neutron velocity selector of the type now being used at the Materials Testing Reactor have been calculated using an IBM-650 computer. Choppers with three types of slits (straight, parabolic, and circular) are considered and burst shapes are presented that show the operating characteristics of such velocity selectors. A function that gives a good fit to many of the burst shapes is presented. The results verify that a circular slit chopper can be used in place of the more exact parabolic slit chopper with only minor distortions in the operating ranges of interest.

5738 THE THEORY AND OPERATION OF THE ROTATING CRYSTAL SLOW NEUTRON CHOPPER.

D.A.O'Connor.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 244-8 (Aug., 1960).

The resolution and efficiency of the rotating-crystal chopper are derived theoretically as a function of the crystal and collimator parameters. It is shown that the limiting resolution of the device is the same as that of a crystal monochromator. An experimental model chopper is described and its observed resolution compared with the theory.

5739 THE USE OF SPARK COUNTERS FOR THE DETECTION OF FAST NEUTRONS.

M.Nachman, L.Schächter and H.Ţoţia.
Stud. Cercetari. Fiz. (Roumania), Vol. 9, No. 4, 497-504 (1958). In Roumanian.

The authors study the possibility of employing spark counters of the Chang and Rosenblum type for the detection of fast neutrons, (energy of a few MeV), by the method of recoil nuclei. Counters with one or more wires, and filled with air, nitrogen, or hydrogen at atmospheric pressure were constructed, and a graphical method was developed to determine the optimum load resistance of the counter. The detectors possess good operating characteristics, a negligible background (lower than 1 pulse per 10 min) and are practically insensitive to γ-radiation. The counters filled with nitrogen are also sensitive to thermal neutrons because of the reaction $N^{14}(n,p)C^{14}$. I.C.Demetsopoullos

AMPLIFIER FOR NEUTRON SPECTROMETRY. See Abstr. 5581

Mesons

5740 CLOSED FORMULAE FOR THE STATISTICAL WEIGHTS.

F.Cerulus.
Nuovo Cimento (Italy), Vol. 19, No. 3, 528-36 (Feb. 1, 1961).

The branching ratios between the different charge distribution of mesons emerging with a given multiplicity from a high-energy colision are computed from isospin conservation and a statistical hypothesis on the probability of the possible end states. The metho uses the Wigner-type of projection operator in group space and yields a closed formula, which is entirely general, for the weights of the different charge states. The formula is especially simple in the case of n isospin 1 particles coupled to a low total isospin. Cases with n isospin 1 particles and one or two isospin $\frac{1}{2}$ particles are simply related to the former result.

5741 RADIATIVE DECAY MODES OF THE MUON.

R.R.Crittenden, W.D.Walker and J.Ballam.
Phys. Rev. (USA), Vol. 121, No. 6, 1823-32 (March 15, 1961).

A 5 in. freon bubble chamber was used to search for the following decay modes of the μ^+ meson:

$$\begin{aligned}&(1)\quad \mu^+ \to e^+ + \gamma,\\ &(2)\quad \mu^+ \to e^+ + e^- + e^+,\\ &(3)\quad \mu^+ \to e^+ + \nu^0 + \bar{\nu}^0 + \gamma,\\ &(4)\quad \mu^+ \to e^+ + \nu^0 + \bar{\nu}^0 + e^+ + e^-.\end{aligned}$$

Two exposures were made with a synchrocyclotron, and the 200 000 pictures taken yielded 3.3×10^5 μ^+-meson decays. 3×10^5 μ^+ decay were examined for mode (1). No decays consistent with this mode were found. The upper limit on the branching ratio R_{rad} was found to be

$$R_{rad} = (\mu^+ \to e^+ + \gamma)/(\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0) < 2.5 \times 10^{-5}.$$

A total of 3.3×10^5 μ^+ decays were scanned for mode (2) and no suc decays were observed. The limit on the branching ratio R_{3e} was found to be

$$R_{3e} = (\mu^+ \to e^+ + e^- + e^+)/(\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0) < 4 \times 10^{-6}.$$

The internal bremsstrahlung rate (mode 3) was measured for two values of $E_{\gamma 0}$ (the minimum photon energy detected). The results were

$$\begin{aligned}R_{IB} &= (\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0 + \gamma)/(\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0),\\ R_{IB} &= (1.4 \pm 0.4) \times 10^{-2}, \qquad E_{\gamma 0} = 10\ \text{MeV},\\ R_{IB} &= (3.3 \pm 1.3) \times 10^{-3}, \qquad E_{\gamma 0} = 20\ \text{MeV}.\end{aligned}$$

The rate of internal conversion of internal bremsstrahlung (mode 4 was found to be

$$\begin{aligned}R_{IC} &= (\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0 + e^+ + e^-)/(\mu^+ \to e^+ + \nu^0 + \bar{\nu}^0) =\\ &= (2.2 \pm 1.5) \times 10^{-5}, \qquad E_0 = 10\ \text{MeV},\end{aligned}$$

where E_0 is the minimum energy of the internally converted γ-ray A summary is given of previous experiments on these decay modes and results are discussed with special reference to the intermediat boson scheme of weak four-fermion interactions.

5472 MEASUREMENT OF THE ANOMALOUS MAGNETIC MOMENT OF THE MUON.

G.Charpak, F.J.M.Farley, R.L.Garwin, T.Muller, J.C.Sens, V.L Telegdi and A.Zichichi.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 128-32 (Feb. 1, 1961).

A short report is given of the measurement of the anomalous magnetic moment of the muon, (g - 2)/2, in the 6 metre magnet at CERN. Longitudinally polarized muons from the synchrocyclotron were degraded to give a radius of 19 cm in the magnetic field. The were caused to step along the magnet by means of a transverse linear field gradient, giving a step of 0.4 cm/turn except for the injection and ejection regions. The polarization direction after ejection was determined from the forward/backward ratio of decay electrons. The time spent by each muon in the field was recorded electronically and found to vary between 2.0 and 6.5 μsec. A value of 0.983 ± 0.019 was obtained for the ratio of (g - 2)/2 to its Dirac value. This enabled limits of 7×10^{-14} cm to be placed on Q.E.D., 4.5×10^{-14} cm on the muon radius, 2×10^{-14} cm on the fundamental length, and ~3×10^{-3} on the coupling constant with a field of nuclear mass. Combination with muon precession measurements ga the muon mass as 206.77 ± 0.01 electron masses. A.Ashmor

5743 CLOUD-CHAMBER STUDY OF HARD COLLISIONS OF COSMIC-RAY MUONS WITH ELECTRONS.

.F.Deery and S.H.Neddermeyer.
hys. Rev. (USA), Vol. 121, No. 6, 1803-14 (March 15, 1961).

The energy distribution of the secondary electrons produced in argets of carbon or paraffin by the μ—e scattering process for uon momenta in the range 5-50 BeV was measured for electron nergies up to 10 BeV, or c.m. momentum transfer up to 100 MeV. vertical array of three cloud chambers immersed in a magnetic eld of 11 000 G was used with a fourfold coincidence system. Two at rectangular proportional counters, suitably biased, together ith two Geiger—Müller trays, provided fair rejection of uneventful enetrating particles and a high efficiency for selection of the arrow electronic showers characteristic of the high-energy electroagnetic events. On 5900 counter-triggered photographs there ere 291 accepted events, having one or more (±) electrons with nergy ≥0.10 BeV, believed to originate in μ—e collisions in the carbon or paraffin) target above the top chamber, from incident uons in the momentum interval 5-50 BeV. The data are compared ith a calculation based on the Bhabha formula for spin $\frac{1}{2}$ muons, aking into account the momentum distribution of the incident muons, e energy loss and shower development in the target and the chamber alls, and a theoretical efficiency factor. Arguments are given to how that direct pair production and bremsstrahlung of the muons the target and in the Pb shield above the apparatus produce egligible effects. The experiment permits a reliable measurement f only the relative distribution. When arbitrarily normalized, the alculated distribution is in fairly good agreement with the data, xcept for a small systematic difference suggesting an excess of bserved events for the harder collisions. Although the discrepancy s interpretable as a statistical fluctuation, the data are fitted much etter over the entire range when the basic cross-section is odified by a "form factor", F^2 (greater than unity), with $= 1 + q^2 \ \lambda_{\mu}^2$ where q is the invariant of the 4-momentum transfer units of h, and λ_{μ} is the Compton wavelength of the muon. This ay be the first indication of a deviation from standard quantum lectrodynamics for hard μ—e collisions. More strongly it shows at, if there is a deviation, it is not representably by a form factor ess than unity.

5744 LIMITS ON THE ANOMALOUS INTERACTIONS OF MUONS AND THEIR MANIFESTATIONS IN HIGH NERGY NUCLEAR SCATTERING.

B.Jouvet and L.Goldzahl.
uovo Cimento (Italy), Vol. 18, No. 4, 702-17 (Nov. 16, 1960).
n French.

Various couplings of the μ-meson with other massive fields are onsidered which might explain the anomalous meson mass. Limits n the corresponding masses and coupling constants are obtained y comparison with the recent data on mesic atoms and the μ-meson nomalous magnetic moment.

J.E.Paton

DIRECT PAIR PRODUCTION BY HIGH ENERGY MUONS.
ee Abstr. 5808

5745 SCATTERING OF μ-MESONS.

R.L.Sen Gupta, S.Ghosh, A.Acharya, M.M.Biswas and .K.Roy.
uovo Cimento (Italy), Vol. 19, No. 2, 245-9 (Jan. 16, 1961).

The scattering of μ-mesons was investigated by means of a ectangular cloud-chamber copper and lead plates placed alterately inside the chamber, μ-mesons after traversing thick layers f iron and lead absorber placed above and below the chamber ere made to stop in 7.6 cm of iron layer by an anticoincidence ethod. The momenta of the scattered μ-mesons were thus wellefined in the region of (1.18 ± 0.05) GeV/c. The observed angular istribution coincides with the point-charge model of the nucleus iven by Moliere in the case of lead, and in the case of copper the istribution is just above the Moliere curve.

5746 PROCESSES OF DEPOLARIZATION OF NEGATIVE MUONS.

A.E.Ignatenko.
uclear Phys. (Internat.), Vol. 23, No. 1, 75-89 (Feb., 1961).

The processes of depolarization of negative muons in different ubstances are investigated by measuring the asymmetry of elecons of the μ—e decay with scintillation counters. It is found that e most intense depolarization of muons occurs after their slowingwn in the formation of mesic atoms. It is shown that there are the llowing causes of the depolarization of muons in the mesic atom:) spin—orbit interaction leading to a fine structure of the energy levels; (b) interaction of the magnetic moment of muons and nucleus responsible for a hyperfine structure of mesic atoms; (c) interaction between the muon and the quadrupole deformation of the nucleus and (d) the interaction between the magnetic moment of the muon and that of the electron shell. The principal features of each process of depolarization are analysed.

5747 ON THE FERMI—YANG THEORY OF THE PIONS.

K.Baumann, P.G.O. Freund and W.Thirring.
Nuovo Cimento (Italy), Vol. 18, No. 5, 906-13 (Dec. 1, 1960).

It is proposed to reduce the strong interactions to the universal weak interaction, by considering them as high energy phenomena of the strongly energy dependent weak interaction. According to Fermi and Yang the pion is assumed to be a nucleon—antinucleon bound state. A method presented in a previous paper is used to solve a Bethe—Salpeter equation. The bound state wave-function is normalized, and the pion—nucleon coupling constant is calculated. The latter turns out to be of the order unity although a weak interaction between the fermions is used.

5748 CONSERVATION OF μ^+-MESON POLARIZATION IN EMULSION WITH AID OF MAGNETIC FIELD.

A.O.Waissenberg and V.A.Smirnitsky.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 23-31 (Feb., 1961).

The space asymmetry coefficient in $\pi^+ \to \mu^+ \to e^+$ decay is measured as a function of external magnetic field in the 0-17 kG range. It is shown that this dependence can be explained by the Paschen-Back effect for muonium and the assumption that there is additional polarization due to charge-exchange at the end of the μ-meson path or due to exchange collisions after the μ-meson has stopped. The minimum value of the asymmetry coefficient for NIKFI-R emulsions is equal to -0.09 ± 0.01 (without a magnetic field); the maximum value is equal to -0.29 ± 0.01 (in a strong field). The 10% difference between the coefficients -0.29 ± 0.01 and -0.33, predicted by the V—A theory, is far outside the limits of experimental errors. Among 340 000 $\pi^+ \to \mu^+ \to e^-$-decays scanned not a single decay into three electrons ($\mu \to 3e$ or $\mu \to e + \nu + \bar{\nu} + \gamma$ with the internal conversion of a γ-ray into an $e^+ - e^-$ pair) was detected.

5749 THE ELECTROMAGNETIC STRUCTURE AND ALTERNATIVE DECAY MODES OF THE π^0.

S.M.Berman and D.A.Geffen.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1192-1202 (Dec. 16, 1960).

It is pointed out that present experiments on the production of single Dalitz pairs in the decay of the neutral pion may yield some information about its electromagnetic structure. It is shown, by means of a dispersion relation, that the distribution of single Dalitz pairs in terms of the virtual photon mass is modified by a simple linear function containing only one unknown parameter, α, which would be of observable magnitude if pion intermediate states give large contributions to the dispersion relation. It is found that, independent of any assumptions about the π^0 structure, the branching ratio for the channel $\pi^0 \to e^+ + e^-$ must be greater than 4.7×10^{-8} and it is estimated that the rate of this decay mode is surprisingly independent of the high energy behaviour of the π^0 electromagnetic structure.

5750 THEORETICAL CONSIDERATIONS ON THE $\pi \to \mu$ DECAY.

S.Ţiţeica.
Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 411-27 (1958).
In Roumanian.

Measurements made at the Institute of Atomic Physics (Roumania) on the disintegration of π-mesons at rest have shown (see Abstr. 280, 7263 of 1958) that the angular distribution of the μ mesons emitted from the decay is anisotropic. Should this observation be correct, it would imply that the spin of the π-meson is non-zero, and that it is at least partially polarized at the moment of disintegration. In the present work the author has set out to calculate the angular distribution of the μ-mesons for an arbitrary value, j, of the spin and an arbitrary value of the polarization of the π-meson. The results are expressed in the form of two formulae which are further simplified for the special cases of j = 1, and j = 2.

S.J.Goldsack

5751 A NOTE ON PHOTO-MESONS FROM DEUTERONS.

V.Devanathan and G.Ramachandran.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 312-18 (Feb., 1961).

The cross-sections for the photo-production of positive pions from deuterons are worked out under impulse approximation using

Chew-Low amplitude of photopion production from nucleons. The numerical results obtained are in reasonable agreement with experimental data.

5752 A MODEL FOR DOUBLE PHOTOPRODUCTION OF CHARGED PIONS. I.

D.Boccaletti and C.Gualdi.
Nuovo Cimento (Italy), Vol. 18, No. 5, 895-905 (Dec. 1, 1960).

Double photoproduction of charged pions is studied taking into account only a diagram with only one exchanged pion. Under the assumption of a sharp pion–pion resonance in the state J = 1, T = 1, making use of an approximate solution for the invariant scattering amplitude F, the energy spectrum of the final protons is calculated at various angles. Such a theory should give at least qualitatively trustworthy results at small momentum transfers of the proton.

5753 EFFECT OF A PION–PION SCATTERING RESONANCE ON LOW ENERGY MESON-PHOTOPRODUCTION.

M.Gourdin, D.Lurié and A.Martin.
Nuovo Cimento (Italy), Vol. 18, No. 5, 933-46 (Dec. 1, 1960).

The influence of the two and three pion intermediate states in the channel $\gamma\pi \to N\bar{N}$ on photoproduction is studied. Application of the Cini–Fubini version of the Mandelstam representation to the amplitude $H^{(0)}$ (isoscalar photon) permits the evaluation of the contribution of a J = I = 1 pion–pion resonance in terms of the isovector nucleon form factors and of the quantities describing the $\gamma + \pi \to \pi + \pi$ amplitude. In the limit of a very narrow resonance the result can be obtained by introducing an isovector vector boson coupled to $\gamma\pi$ and to $N\bar{N}$. This contribution can be merely added to the previous evaluations of $H^{(0)}$, since rescattering corrections are negligible at low energies. Arguments are given to show that the only important three-pion state is a resonant I = 0, J = 1 state which is crudely described by an isoscalar vector boson. Some of the parameters entering in this calculation can be obtained from experimental information on the isoscalar nucleon form factors. Though the three pion contribution to $H^{(+)}$ (isovector photon) is very simple, the final result is obtained in a more complicated way because rescattering corrections are important. Through crossing, $H^{(-)}$ (isovector photon) is also affected. It seems that one of the most interesting quantities to consider, in order to compare theory and experiment, is the $d\sigma^+/d\sigma^-$ ratio and its dependence on energies and angles.

5754 COULOMB PHOTOPRODUCTION OF π^0 AT HIGH ENERGY AND π^0 LIFETIME.

C.Chiuderi and G.Morpurgo.
Nuovo Cimento (Italy), Vol. 19, No. 3, 497-511 (Feb. 1, 1961).

A discussion is presented of the possibility of determining the lifetime of the π^0 using the photoproduction of π^0 in a Coulomb field as suggested by Primakoff. It is first shown how the competition with coherent nuclear production makes it necessary to use a rather high photon energy. Even at 1 GeV, however, the Coulomb photoproduction dominates over the coherent nuclear one only in a very narrow cone around the forward direction; this cone has an angle of $\sim 3^0$ for $\tau = 5 \times 10^{-17}$ sec and only 2^0 for $\tau = 5 \times 10^{-16}$ sec. Assuming that the difficult technical problems connected with these small angles may be solved, it is still necessary to prove that, at these small angles, the incoherent production is not dominant. Indeed, though the incoherent production is certainly smaller than the coherent nuclear one by a factor of A (= mass number), the incoherent cross-section does not have the factor $\sin^2\theta$ which affects both the Coulomb and the nuclear coherent cross-sections. A calculation of the incoherent photoproduction of π^0 at small angles is therefore made using a multipole expansion and sum rules. It is shown that, for lead, the incoherent cross-section at small angles is at most of the same order of magnitude of the nuclear coherent one so that it does not dominate the picture. For light nuclei the competition between incoherent and coherent nuclear production at small angles is more unfavourable and depends rather critically on the properties of the individual nucleus chosen. It is concluded that heavy nuclei are the most suited for the experiment and that, at 1 GeV, only lifetimes shorter than some units times 10^{-16} may possibly be measured by this method.

5755 EFFECTS OF THE NUCLEAR BINDING OF NUCLEONS ON PION SPECTRA.

H.Helfer, A.S.Kuznetsov, M.G.Mescheryakov, W.Swiatkowski and V.G.Vovchenko.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 353-67 (March, 1961).

Using a magnetic spectrometer a comparative study was made of the energy spectra of π^+ and π^--mesons produced in free pp-collisions as well as in pp- and pn-collisions in deuterons and in carbon nuclei at 654 MeV. The forms of the spectra of pions from deuterium and carbon were found to differ due to: (a) a larger extent of correlation of nucleons in carbon nuclei than in deuterons; (b) differences in the momentum distributions of nucleons in these nuclei; (c) secondary pion–nucleon interactions in carbon nuclei. At $\sim 90^0$ in the centre-of-mass system of two colliding nucleons the ratio of the differential cross-sections for the production of π^+-mesons on free protons and on protons in deuterons and in carb nuclei was

$$\frac{d\sigma}{d\omega}[p + p \to \pi^+]_H : \frac{d\sigma}{d\omega}[p + p \to \pi^+]_D :$$

$$\frac{d\sigma}{d\omega}[p + p \to \pi^+]_C = 1 : 0.79 : 0.40,$$

whereas the yields of π^--mesons per neutron for deuterium and carbon were found to be equal. The measured ratios $(d\sigma^+/d\omega)/(d\sigma^-/d\omega$ of the differential cross-sections for the production of positive and negative pions on deuterium and carbon were 10.3 ± 1.3 and 6.0 ± 0.8, respectively. The decrease of the value of this ratio for carbon is caused by a considerable contribution of the secondary exchange interaction $\pi^0 + n \to \pi^- + p$ to the yield of π^--mesons.

5756 PION PRODUCTION BRANCHING RATIOS THROUGH THE 900 MeV RESONANCE.

B.A.Munir, E.Pickup, D.K.Robinson and E.O.Salant.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 192-3 (Feb. 15, 1961).

The branching ratio for positive to neutral pion production in π^-,p collisions at 905 ± 2 MeV were measured as 1.70 ± 0.17. The new value indicates an approximately constant ratio between 800 and 1100 MeV, and so removes the need for a pion–pion resonance in the t = 1 state found by Carruthers and Bethe (Abstr. 15397 of 1960). D.W.L.Sprun

5757 PHOTOPRODUCTION AND DETECTION OF THE TWO-MESON BOUND STATE.

J.L.Uretsky and T.R.Palfrey, Jr.
Phys. Rev. (USA), Vol. 121, No. 6, 1798-1803 (March 15, 1961).

The possibility of detecting a photoproduced two-pion bound system is investigated. The general detection problem is discusse briefly; the branching ratio between $2\pi^0$ and $2\gamma^0$ decay modes is calculated; and the total photoproduction cross-section is estimate in terms of the binding energy of the two-pion state both by field-theoretic and by phase-space arguments. It is concluded that if the binding energy is of the order of 10 MeV the state should be detectable in photoproduction experiments, and the binding energy should be measurable.

5758 CENTRAL AND PERIPHERIC INTERACTIONS OF 7.3 GeV NEGATIVE PIONS IN EMULSIONS.

E.M.Friedländer, M.Marcu and M.Spîrchez.
Nuovo Cimento (Italy), Vol. 18, No. 4, 623-31 (Nov. 16, 1960).

534 interactions of 7.3 GeV negative pions in an emulsion stac were studied. Average multiplicities of heavy prongs and shower particles were obtained. Individual Lorentz factors γ_c were computed for 395 showers with $n_s \geq 3$. A detailed study is made of the γ_c-spectrum of events from light nuclei. This spectrum appears structured into head-on collisions with one or two nucleons and per pheric collisions involving one or two pions in the struck nucleon's meson cloud. Pion–pion collisions show a marked "two-centre" structure, attributed tentatively to the formation and isotropic two pion decay of pionic resonant (isobaric) states of mass $\sim 3\ \mu$. The e^-–e^+-pair spectrum from π^0-decay has been measured and yields an average inelasticity of ~ 75% in π^-–nucleus collisions.

5759 PION–PION INTERACTION FROM π PRODUCTION IN πN COLLISION.

F.Bonsignori, V.Bortolani and A.Stanghellini.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1237-46 (Dec. 16, 1960).

The Chew and Low model for the determination of the π–π cross-section is used for the analysis of an experiment of pion production by pions. The one-pion-exchange model and the possibl π–π resonances are discussed.

5760 THEORY OF THE LOW-ENERGY PION-PION INTERACTION. II.

G.F.Chew and S.Mandelstam.
Nuovo Cimento (Italy), Vol. 19, No. 4, 752-76 (Feb. 16, 1961).

For Pt I, see Abstr. 13019 of 1960. It is shown that when P-wave pion-pion scattering is large at low energies, the integral equations previously formulated by the authors require a cut-off. Because of the cut-off and the unstable nature of the solution, the numerical integration procedure becomes much more involved. The original equations are therefore replaced by a series of conditions at the symmetry point, and the unphysical cuts of the partial-wave amplitudes are replaced by a corresponding series of poles. Within this framework one need not speak of a cut-off, but one new parameter appears. Self-consistent solutions can be found in which a P-wave resonance is sustained by a "bootstrap" mechanism; that is, a strong attractive force in the I=1 state results from the exchange of a resonating pair of P-wave pions. The symmetry-point conditions used would be modified by the cut-off and quantitative accuracy is not attempted; however, this and other corrections are not expected to change the qualitative nature of the solutions. Rough estimates of the corrections are made.

5761 INTERMEDIATE BOSON PRODUCTION IN PION—PROTON COLLISIONS. N.Dombey.

Phys. Rev. Letters (USA), Vol. 6, No. 2, 66-8 (Jan. 15, 1961).

The cross-section for producing the intermediate boson of weak interaction theory in pion—proton collisions is calculated, using the analogy with pion photoproduction and taking only the vector interaction into account. The nucleon form factor, which is required for unphysical argument, is calculated in terms of a pion—pion resonance. The result is uncertain by a factor of the order of 100, depending on the parameters of this resonance. The cross-section for producing a boson of mass about four nucleon masses has a greatest value of about 10^{-30} cm^2 when only the Born term is considered. An estimate of the effect of the 3-3 pion—nucleon resonance on this value suggests that it may increase it by a factor of the order of 100. E.J.Squires

5762 TEST FOR PION—PION RESONANCE.
G.Pinski.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 136-8 (Feb. 1, 1961).

It is shown that the reaction $p + n \rightarrow \pi^- + \pi^- + \pi^+$ should be sensitive to a pion—pion resonance; in particular the effective mass squared variable $(p_1 + p_2)^2$ should show significant differences between like and unlike pion pairs. D.W.L.Sprung

5763 RELATION BETWEEN π—N SCATTERING AND NUCLEON STRUCTURE THROUGH $\pi\pi$ INTERACTION.
A.Stanghellini.

Nuovo Cimento (Italy), Vol. 18, No. 6, 1258-64 (Dec. 16, 1960).

The relation between long range effects in pion—nucleon scattering and nucleon structure through pion—pion interaction inthe $T = 1$, $J = 1$ state is analysed by means of different models.

5764 THE EFFECT OF A PION—PION INTERACTION ON LOW-ENERGY MESON-NUCLEON SCATTERING. II.
J.Bowcock, N.Cottingham and D.Lurié.

Nuovo Cimento (Italy), Vol. 31, No. 1, 142-53 (Jan. 1, 1961).

Using the formalism developed in Pt I (Abstr. 15408 of 1960) the consequences of a pion—pion interaction on low energy pion—nucleon phase shifts is investigated. By confining consideration to the isotopic spin flip combination of waves the effects due to a pion—pion interaction in the $T = 1$ state is isolated. It is found that such an interaction is definitely necessary to give agreement with experiment and that a simple resonance in the $J = 1$, $T = 1$ state gives a good fit to the data.

5765 π^- + p ELASTIC SCATTERING AT 1200 MeV.
L.Bertanza, R.Carrara, A.Drago, P.Franzini, I.Mannelli, G.V.Silvestrini and P.H.Stoker.

Nuovo Cimento (Italy), Vol. 19, No. 3, 467-81 (Feb. 1, 1961).

A bubble chamber investigation of π^-+ p elastic scattering at 1200 MeV (K.E.) is reported. The total and differential cross-sections are determined. By extrapolation of the angular distribution, the 0° cross-section is derived and compared with the results obtained with the help of dispersion relations and the optical theorem. The forward peak is investigated in terms of diffraction scattering and a value for the optical radius is derived.

5766 ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 128 AND 162 MeV.
Yu.A.Budagov, S.Wiktor, V.P.Dzhelepov, P.F.Yermolov and V.I.Moskalev.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 226-44 (Jan., 1961).

The elastic scattering distribution of negative pions by protons was measured with a hydrogen-filled diffusion cloud chamber in a magnetic field, In a set of exposures 344 and 941 elastic scattering events were recorded for 128 and 162 MeV respectively at angles θ(c.m.s.) > 10°. The total cross-sections for elastic scattering σ_{el} (128 MeV) = (12.8 ± 1.0) 10^{-27} cm^2 and σ_{el} (162 MeV) = (21.4 ± 1.2) 10^{-27} cm^2 were determined by calculating the total length of negative pion tracks in the chamber. The elastic π^-—p-scattering angular distributions were obtained in the form (the SP-analysis):

$$d\sigma/d\Omega(128\ \text{MeV}) = (1.00 \pm 0.08)\ [(0.55 \pm 0.07) + \\ + (0.34 \pm 0.12)\cos\theta + (1.30 \pm 0.24)\cos^2\theta]\ 10^{-27}\ \text{cm}^2/\text{sr},$$

$$d\sigma/d\Omega(162\ \text{MeV}) = (1.00 \pm 0.06)\ [(0.93 \pm 0.07) + \\ + (0.51 \pm 0.12)\cos\theta + (2.28 \pm 0.22)\cos^2\theta]\ 10^{-27}\ \text{cm}^2/\text{sr}.$$

The differential forward scattering cross-sections are equal to (2.20 ± 0.32) 10^{-27} cm^2/sr and (3.73 ± 0.32) 10^{-27} cm^2/sr respectively. The real parts of the forward scattering amplitude (in c.m.s.) was calculated in units of $\hbar/m_\pi c$:

$$D_-^b(128\ \text{MeV}) = 0.261 \pm 0.031 \text{ and } D_-^b(162\ \text{MeV}) = 0.216 \pm 0.038.$$

These quantities agree with those calculated from dispersion relations with the coupling constant $f^2 = 0.08$.

5767 $\pi\pi$ INTERACTIONS IN πN-COLLISIONS AT HIGH PION ENERGIES. D.I.Blokhintsev and Wang Yung.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 410-25 (Feb., 1961).

The role of the peripheral $\pi\pi$ interaction in πN collisions is studied when the energy of the primary pion is about 7 GeV. It is shown that in elastic πN scattering the contribution of the peripheral $\pi\pi$ interaction is not great, and that it is fully masked by the diffraction scattering from the nucleon core. In the case of inelastic collisions the contribution of the $\pi\pi$ interaction is quite noticeable and, therefore, it is possible to determine the cross-sections for $\pi\pi$ interaction from the experimental data on multiple-pion production. The distribution of the transverse momentum of the recoil nucleon is calculated in the processes $\pi + N \rightarrow N + 2\pi$, and of Λ^0 for the process $\pi + N \rightarrow \Lambda^0 + K + \pi$. It is shown also that this distribution is in agreement with the experimental data.

5768 APPROXIMATE EQUATIONS FOR PARTIAL π—K SCATTERING AMPLITUDES.
P.S.Isaev and M.Sewerynski.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 663-76 (Feb., 1961).

Approximate integral equations for partial π—K scattering amplitude are obtained with the help of the double Mandelstam representation in the low-energy range.

5769 ON THE $\pi^- + p \rightarrow \Lambda^0 + K^0$ AMPLITUDE.
R.J.N.Phillips.

Nuclear Phys. (Internat.), Vol. 23, No. 2, 345-8 (Feb., 1961).

Two ways to resolve a certain phase-ambiguity, arising in the S + P wave analysis, are pointed out.

5770 MEASUREMENT OF THE TOTAL CROSS-SECTION OF π^+—p AND π^-—p FROM 400 MeV TO 1.5 GeV.
J.C.Brisson, J.F.Detoeuf, P.Falk-Vairant, L.Van Rossum and G.Valladas.

Nuovo Cimento (Italy), Vol. 19, No. 2, 210-33 (Jan. 16, 1961).

Measurement of the total cross-sections by attenuation in liquid hydrogen of a beam whose energy was known to ±1% and with a total $\Delta P/P$ of ±1.8%. The energies and values found for the cross-sections at maxima are

π^-: $T\pi_{lab}$ = (605 ± 6) MeV, σ_{tot} = (45.8 ± 1.8) mb,
$T\pi_{lab}$ = (890 ± 9) MeV, σ_{tot} = (58.0 ± 1.8) mb,
π^+: $T\pi_{lab}$ = (1330 ± 30) MeV, σ_{tot} = (38.0 ± 2.0) mb.

There is a compilation of results concerning the elastic and inelastic cross-sections obtained by other experimental techniques in the neighbourhood of the second and third π^- resonances. Finally there is a discussion of the second and third resonances.

5771 ON THE SEPARATION OF π^+ MESONS BY A TIME OF FLIGHT METHOD.
G.M.Lewis, E.Gabathuler and R.E.Azuma.

Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 230-2 (Aug., 1960).

A time-analysing coincidence unit of short resolving time has been employed to separate photoproduced π^+ mesons from electrons and protons by a time of flight method. The positive pions are additionally identified by their decay characteristics, so that an assessment of the method as a mass discriminator can be made.

5772 A SCINTILLATION COUNTER SYSTEM FOR THE DETECTION OF POSITIVE AND NEGATIVE PIONS.

J.G.Rutherglen and J.K.Walker.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 239-43 (Aug., 1960).

A three-counter telescope is described in which pions are separated from particles of different mass by measurement of dE/dx and E. Identification of positive pions is made by means of the characteristic $\pi^+-\mu^+$ decay. The arrangements for recording this information both photographically and by means of a pulse-height analyser are described.

5773 π^- STAR DETECTOR.

A.F.Dunaitzev, Yu.D.Prokoshkin and Tang Syao-Wei.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 1, 11-18 (July, 1960).

A scintillation detector possessing the selective sensitivity to π^- mesons is described. The detector records the stars due to π^- mesons coming to rest.

5774 NUCLEAR POTENTIAL FOR THE K^+-MESON.

T.G.Lim and S.J.Bosgra.
Nuovo Cimento (Italy), Vol. 19, No. 2, 239-44 (Jan. 16, 1961).

Data of K^+-mesons elastically scattered by complex nuclei in G-5 nuclear emulsion are analysed. Only small angles in the energy region of (40-80) MeV are considered. The phase-shift optical model analysis is applied, using the W.K.B.J. approximation for the evaluation of phase shifts. The calculations are based on the assumption that the elastic nuclear scattering potential may be approximated by a real square model. The magnitude is estimated to be (21 ± 5) MeV, if in the relation of the nuclear radius $R = r_0A^{1/3}$, $r_0 = 1.2 \times 10^{-13}$ cm, and it is (17 ± 5) MeV, if $r_0 = 1.4 \times 10^{-13}$ cm.

5775 POSSIBLE EXISTENCE OF A NEW K' MESON.

J.Tiomno, A.L.L.Videira and N.Zagury.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 120-3 (Feb. 1, 1961).

To explain the strong backward peaking of the Λ's produced in π—p collisions, without requiring opposite parities for the K^+ and K^0, a new meson, K'^+, is proposed, interacting strongly with K and π. The experimental data suggest that K' should be scalar, of mass about 605 MeV, and decaying strongly into K and π. Its existence should show up in the momentum spectrum of Λ in the reaction $\pi + N \rightarrow K + \pi + \Lambda$, or of the nucleon in the reaction $K + N \rightarrow K + \pi + N$.

R.F.Peierls

5776 K—π RESONANCE AND LIFETIME OF THE K' PARTICLE.

M.A.Baqi Bég and P.C.De Celles.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 145-6 (Feb. 1, 1961).

The lifetimes and spins of the conjectured K' and K_V particles are related to their production cross-section in K^-—p scattering. It is suggested that a strong backward peaking would be evidence for K' rather than K_V. Also, from the available cross-section and experimental lifetime the K' alternative is indicated.

J.S.Dowker

5777 SOME RARE DECAY MODES OF THE K-MESON.

N.Cabibbo and E.Ferrari.
Nuovo Cimento (Italy), Vol. 18, No. 5, 928-32 (Dec. 1, 1960).

In view of future experiments with high intensity K-meson beams the branching ratios for $K^\pm \rightarrow \pi^\pm + e^+ + e^-$ and $K_1^0 \rightarrow 2\gamma$ are evaluated.

5778 A CONTRIBUTION TO THE K^+-DECAY STATISTICS.

J.K.Bøggild, K.H.Hansen, J.E.Hooper, M.Scharff and P.K.Aditya.
Nuovo Cimento (Italy), Vol. 19, No. 4, 621-41 (Feb. 16, 1961).

K^+-decay events in a large block of emulsions were studied, mainly by following the charged secondaries to the ends of their ranges. Emphasis was laid on: (1) obtaining unbiassed information on the high energy end of the spectrum of the $K_{\mu 3}$ secondary; (2) a search for a decay mode $K^+ \rightarrow \mu^+ + \mu^0$; when combined with the results of earlier experiments the data were such that it should have been possible to detect the process if the branching ratio was greater than ≅ 5%; no positive evidence was found; (3) a search for π^+ secondaries of energy (53-61) MeV. Among 467 decay events there were no such secondaries. The branching ratios for the various decay modes were determined. Combining this data with those of previous experiments the following values were obtained: $B(K_{\mu 2}) = (58.6 \pm 2.6)\%$; $B(K_{\pi 2}) = (21.7 \pm 2.5)\%$; $B(K_{\pi 3}) = (7.1 \pm 0.4)\%$; $B(K_{\pi 3}') = (2.4 \pm 0.4)\%$; $B(K_{\mu 3}) = (5.5 \pm 1.1)\%$; $B(K_{\beta 3}) = (4.7 \pm 1.1)\%$. The measured scanning efficiency in this experiment was 99%.

5779 ON THE $K_{\mu 3}$ AND K_{e3} DECAY MODES.

N.Brene, L.Egardt and B.Qvist.
Nuclear Phys. (Internat.), Vol. 22, No. 4, 553-78 (Feb., 1961).

On the basis of the usual local current-current coupling betwe the lepton fields and the boson fields some general expressions are obtained for the muon (electron) and pion spectra and the muon polarization in an arbitrary direction taken as a function of the muon energy. The derivation of the muon spectrum and polarizati involves a phase space integration over the pion momenta, on whic however, the two unknown form factors $f_\pm(p_\pi p_K)$ describing the effect of strong interactions are dependent. By means of a covariant integration technique originally due to Berman the phase space integral is recast into a sum of products of factors dependin on the muon and kaon momenta alone and very simple integrals ove the form factors. These integrals depend on the muon and kaon momenta only through their upper and lower limits. In the c.m.s. of the decaying kaon the factors depend solely on E_1, the muon or electron energy. The general expressions are applied to two special examples: constant form factors and form derived by MacDowell by means of a dispersion technique. The results for these cases are very much alike.

5780 ON THE PARITY CONSERVATION IN THE REACTION $K^- + p = \Sigma^+ + \pi^-$.

A.Caforio, A.Ferilli, D.Ferraro, M.Merlin, L.Guerriero, I.Laboragine, G.A.Salandin, F.Waldner, G.Poiani and M.de P.Cagnodo.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1174-83 (Dec. 16, 1960).

143 protonic decays of Σ^+, emerging from K^- capture stars in nuclear emulsion were analysed in order to detect the possible parity non-conservation in the strong capture reaction. The forwa backward asymmetry A of the decay was determined, obtaining the value A = (4.4 ± 7.8)%. This result is in accordance with the hypothesis of strict parity conservation.

5781 INFLUENCE OF THE $\Lambda\pi$ RESONANCE ON CORRELATIONS IN THE REACTION $K^- + d \rightarrow \Lambda + \pi^- +$

O.I.Dahl, N.Horwitz, D.H.Miller, J.J.Murray and P.G.White.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 142-4 (Feb. 1, 1961).

New data on the recoil proton spectrum shows structure which can be explained in terms of a $\Lambda\pi$ resonance at 1382 MeV of half-width 20 MeV. Possible angular distribution correlations are discussed. No data are available for these yet.

J.S.Dowk

5782 ELASTIC SCATTERING OF LOW ENERGY K^- MESONS ON PROTONS.

D.H.Davis, R.D.Hill, B.D.Jones, B.Sanjeevaiah, J.Zakrzewski and J.P.Lagnaux.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 132-4 (Feb. 1, 1961).

Emulsion data from the European K^- collaboration were scann for low-energy K^-—p elastic scattering events. 56 events were sourted into 5 momentum intervals covering the range 53-253 MeV They indicate that the cross-section is still rising at the lowest momentum, which is contrary to some previous data. Possible faults in the earlier data are considered. The present results suggest constructive Coulomb interference.

A.Ashmor

5783 $\bar{K}$ CAPTURE FREQUENCY IN HYDROGEN.

A.A.Kamal.
Nuovo Cimento (Italy), Vol. 19, No. 4, 738-41 (Feb. 16, 1961).

From the study of $\bar{K}$ capture stars in photographic emulsions, the $\bar{K}$ capture frequency in the hydrogen atom is estimated and the result is compared with the Fermi—Teller theory of the capture of negative mesons in matter. A strong disagreement is found from expected value. This discrepancy has been attributed to the transfer of the meson to an atom of the CNO group.

Hyperons

5784 ON THE PION—HYPERON RESONANCES AND ON THE POSSIBLE USES THEREOF. (DETERMINATION OF THE Σ—Λ RELATIVE PARITY AND OF THE α_Λ/α_0 RATIO).

P.Meyer, J.Prentki and Y.Yamaguchi.
Nuovo Cimento (Italy), Vol. 19, No. 4, 794-815 (Feb. 16, 1961).

The existence of a resonance in the hyperon—pion system lea to a possibility of determining the $\Sigma-\Lambda$ relative parity and the rati α_Λ/α_0 of asymmetry coefficients α_Λ (in $\Lambda \rightarrow p + \pi^-$) and α_0 (in $\Sigma^+ \rightarrow p + \pi^0$). In this paper a proposal is made which allows the determination of these quantities by measuring only the up/dow asymmetries of pions coming from Λ- and Σ-decays. Various spects of this proposal are discussed. The possible existence of ther resonances is also emphasized. In particular it is shown that ie existence of a resonance in the isotopic spin state I = 1 leads to ome predictions concerning the existence of another resonance, robably in the I = 2 state.

5785 ELECTROMAGNETIC SCATTERING OF HYPERONS.

M.J.Englefield and B.Margolis.

Nuovo Cimento (Italy), Vol. 19, No. 2, 274-6 (Jan. 16, 1961).

The interaction between the magnetic moment of a neutral yperon and the charge of a nucleus causes large polarizations in small-angle scattering. The feasibility of using the effect to measure he magnetic moment is considered.

5786 EFFECT OF FINAL STATE INTERACTIONS ON THE (Σ^-, d) CAPTURE REACTIONS.

Yung Yi Chen.

Nuovo Cimento (Italy), Vol. 19, No. 1, 36-45 (Jan. 1, 1961).

The effects of the two neutron final state interaction in the eaction $\Sigma^- + d \rightarrow (\Lambda^0 \text{ or } \Sigma^0) + n + n$ are calculated using the impulse pproximation with the assumption of S-wave absorption and even elative parity between hyperons. Comparing the results with those eglecting all final state interactions, one finds that the Σ^0 producion can be enhanced by a factor ~ 6 while the Λ^0 production is increased by only ~10%. The most recent experimental results on the oranching ratio of the two hyperon-productions can now be fitted vith a less extreme assumption about the spin dependence of the ransition matrix for the reaction $\Sigma^- + p \rightarrow \Sigma^0 + n$, although an ppreciable amount of spin dependence is still required. The effect of the dineutron final state interaction on the Λ^0 momentum spectrum s calculated as a function of the spin dependence of the Λ^0 production process. The present experimental data, however, are not sufficient o determine this spin dependence.

5787 DIRECT Ξ DECAY AND MUONIUM–ANTIMUONIUM TRANSITIONS.

S.L.Glashow.

Phys. Rev. Letters (USA), Vol. 6, No. 4, 196-7 (Feb. 15, 1961).

It is pointed out that the argument from the small mass lifference between K_1^0 and K_2^0 that $\Delta S = 2$ interactions cannot exist only applies to those interactions which are even under charge conjugation. For an odd interaction CP invariance requires odd parity as vell, and hence direct Ξ decay will show no asymmetry similar rguments apply to the use of muonium–antimuonium transitions to ook for interactions permitting $e^- + e^- \rightarrow \mu^- + \mu^-$. R.F.Peierls

5788 Ξ^- PRODUCTION BY K^- MESONS.

W.B.Fowler, R.W.Birge, P.Eberhard, R.Ely, M.L.Good, V.M.Powell and H.K.Ticho.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 134-6 (Feb. 1, 1961).

The Berkeley 30 in. propane bubble chamber was used in a .17 GeV/c K^- beam at the Bevatron. 18 positively identified $\Xi^- \rightarrow \Lambda + \pi^-$ decays were obtained in 100 000 pictures. These gave $M_{\Xi^-} = 1317.9 \pm 1.9$ MeV. From the gap lengths the lifetime of the Ξ^- was estimated to be $(1.28^{+0.41}_{-0.25}) \times 10^{-10}$ sec. From the orward/backward asymmetry in the Λ decay the Λ is found to be olarized with the strength, $\alpha_{\Xi} = 0.69 \pm 0.36$. There was no vidence of the Ξ^- being polarized. The production cross-section vas estimated to be 18 ± 5 μb/nucleon. A.Ashmore

Deuterons

5789 RELATIVISTIC DEUTERON WAVE FUNCTION. II.

M.Gourdin and J.Tran Thanh Van.

Nuovo Cimento (Italy), Vol. 18, No. 3, 443-57 (Nov. 1, 1960).

For Pt I, see Abstr. 7421 of 1960. The Bethe and Salpeter elativistic wave-equation is applied to the bound system of two articles with spin $\frac{1}{2}$. After some very slight approximations, the olution of the infinite system of coupled integral equations enables ie explicit structure of the wave matrices to be found corresponing to the S and D states. The percentage of D state obtained is good agreement with the experimental results.

5790 DEUTERON ELECTRIC QUADRUPOLE MOMENT.

J.P.Auffray.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 120 (Feb. 1, 1961).

The deuteron quadrupole moment is recalculated from the measured quadrupole coupling constant, giving a value $Q = 2.82 \times 10^{-27}$ cm^2, about 3% larger than the previous value. The difference in the calculation is in the choice of trial wave-function used to determine the electric field gradient at the deuteron. R.F.Peierls

5791 BREAKUP OF DEUTERONS ON H, D, He^3 AND He^4.

B.V.Rybakov, V.A.Sidorov and N.A.Vlasov.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 491-8 (March, 1961).

Continuous neutron energy spectra produced by bombardment of H, D, He^3 and He^4 with 18.6 MeV deuterons and D with 8.6 MeV protons and 34.6 MeV alpha-particles were studied by the time-of-flight technique. Peaks in the neutron spectra from the p + d and α + d reactions were observed which are satisfactorily explained by pair interactions between the reaction products in the final state. No such peaks were found in the spectra of the d + d and He^3 + d reactions. Their shape also differs significantly from that corresponding to the statistical distribution of energy between the three particles in S-states of relative motion, but can be easily explained by the presence of higher angular momenta in the final state.

5792 ON THE EFFICIENCY OF THE REACTION $H^3(d, n)He^4$ IN TITANIUM TRITIDE BOMBARDED WITH DEUTERONS.

E.M.Gunnersen and G.James.

Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 173-84 (Aug., 1960).

The lack of accurate energy loss data in metals (and particularly in titanium tritide) of deuterons of less than 100 keV has been shown to cause large uncertainties in calculations of the neutron yield produced by the $H^3(d, n)He^4$ reaction when a titanium tritide target is bombarded with low energy deuterons. Direct measurements of the energy loss in titanium hydride foils of 40-150 keV deuterons were made, and were used in combination with data in the literature for other metals and higher ion energies to recalculate the neutron yield from this $H^3(d, n)He^4$ reaction in titanium tritide for for the deuteron energy range 9-150 keV. Using this yield curve, a technique is described for estimating how tritium concentration varies with depth in the titanium tritide material by examining the observed variation of neutron yield with incident angle and energy of the bombarding deuteron beam. It is found that the concentration peak is never less than 3000 A below the surface, and that there is very little tritium contained in an upper surface layer of about 500 A, or in the lower one-third of the titanium tritide material.

THE NEUTRON SPECTRUM OF THE d + p REACTION. See Abstr. 4798

POTENTIAL MODEL OF DEUTERON PHOTODISINTEGRATION AND MANDELSTAM REPRESENTATION. See Abstr. 5676

Tritons

5793 BINDING ENERGY OF THE TRITON

G.Derrick, D.Mustard and J.M.Blatt.

Phys. Rev. Letters (USA), Vol. 6, No. 2, 69-70 (Jan. 15, 1961).

An outline is given of a variational calculation of the binding energy, using the nuclear force proposed by Brueckner and Gammel to fit the properties of nuclear matter. After varying some 40 parameters the binding energy comes out to be less than −10 MeV, which is to be compared with an experimental value of −8.49 MeV. Since the error in the numerical evaluation of the expectation value of the Hamiltonian is estimated to be less than 0.3 MeV, it is concluded that the Brueckner–Gammel potential is inconsistent with the experimental binding energy of the triton. The sensitivity of the result to a large number of variational parameters suggests that simple approximations are unlikely to give accurate answers. E.J.Squires

Alpha-particles

5794 MATRIX ELEMENTS FOR THE ALPHA-PARTICLE.

L.Cohen.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 492-7 (Feb., 1961).

The classification of alpha-particle wave-functions given in an earlier paper is reformulated in terms of products of vectors and products of tensors. It is shown how, after summing over spins and isobaric spins, the matrix elements may be expressed in terms of functions of interparticle distances only.

5795 TRANSISTOR ALPHA-PARTICLE DETECTOR.
C.S.Ananiades and J.W.Dewdney.
Amer. J. Phys., Vol. 29, No. 5, 329 (May, 1961).

Demonstration apparatus.

5796 THE ELASTIC SCATTERING OF ^{3}He BY C, Mg, Al AND Cu. G.Parry, H.D.Scott and S.Swierszczewski.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 230-3 (Feb., 1961).

Angular distributions of 5.5 MeV He^3 particles elastically scattered by C, Mg, Al and Cu were measured by magnetic analysis at angles of observation between 20° and 132.5°. The curves of the ratio of observed cross-section to calculated Coulomb cross-section show a decrease with angle for C, Mg and Al and an increase at large angles for Cu. The curves also show maxima and minima.

COSMIC RAYS

(Nuclear reactions due to cosmic rays are included under Nuclear Reactions)

HODOSCOPE FOR LOW LEVEL OUTPUT PARTICLE DETECTORS. See Abstr. 4745

BF$_3$ PROPORTIONAL COUNTERS FOR COSMIC-RAY NEUTRONS. See Abstr. 5607

5797 STUDY OF THE COSMIC-RAY SOFT COMPONENT BY THE 3rd SOVIET EARTH SATELLITE.
S.N.Vernov, A.E.Chudakov, E.V.Gorchakov, J.L.Logachev and P.V.Vakulov.
Planet. Space Sci. (GB), Vol. 1, No. 2, 86-93 (April, 1959).

Measurements made with a scintillation counter installed on the 3rd Soviet earth satellite are presented. By this instrument the counting rate corresponding to the energy greater than 35 keV and the total ionization in the scintillator were measured. Two zones of high intensity radiation are observed. The first one is observed on latitudes greater than 60° and altitudes above 300 km. Radiation in this "polar zone" consists of electrons of energy about 100 keV and flux rate of 10^3 to 10^4 particles cm^{-2} sec^{-1} sterad^{-1} (increasing with altitude). The second zone is observed on altitudes about 100 km and latitudes not exceeding 50°. In this "equator zone" the ionization in the scintillator is 3 orders of magnitude greater than that due to cosmic-rays. Strong dependence on latitude and longitude is assumed to be consistent with the symmetry of the zone relative to the inclined and displaced geomagnetic axis. Lower limits are given for the γ-radiation from the Sun.

5798 ČERENKOV RADIATION IN THE ATMOSPHERE.
J.V.Jelley.
Planet. Space Sci. (GB), Vol. 1, No. 2, 105-11 (April, 1959).

The bursts of large numbers of electrons produced in the atmosphere by cosmic-ray air showers, give rise to Cherenkov radiation in the air. The showers are therefore accompanied by light pulses of short duration; these may be detected quite easily with simple apparatus on a clear dark night. The article reviews the theoretical and experimental work that has been done up to the present time, and discusses the potentialities and limitations of the technique as a new tool for cosmic-ray research. The paper concludes with remarks on the future possibilities in this field, and the likely technical developments.

5799 A MONTE-CARLO CALCULATION OF THE PRODUCTION SPECTRUM OF MESONS IN JETS.
M.Marcu and M.Spîrchez.
Nuclear Physics (Internat.), Vol. 21, No. 3, 526-7 (Dec. (1) 1960).

A sample of 200 values of the momentum of the secondaries in high-energy meson jets was computed by means of a Monte-Carlo procedure, starting from experimental observed facts such as the Gaussian distribution of log p_T and the isotropy in the emitting centre system. The shape of the spectrum of p-values does not agree with dp/p^2.

5600 ANALYSIS OF SOME NUCLEAR INTERACTIONS OF ENERGIES $(10^{12}$-$10^{14})$eV/NUCLEON.
P.K.Malhotra and Y.Tsuzuki.
Nuovo Cimento (Italy), Vol. 18, No. 5, 982-1002 (Dec. 1, 1960).

Five nuclear interactions produced by nuclei with values of charge Z = 1, 2, 6, 7 and 14 and with energies between 10^{12} and 10^{14} eV/nucleon are described. The angular distributions and the momentum distributions of the secondary particles produced in thes jets are studied. Assuming transverse momentum to be constant, th momentum spectrum in the c.m. system in the case of each of the three jets with energies between $(10^{13}$-$10^{14})$eV/nucleon is found to be of the form $P^{-2}dP$. Twenty nuclear interactions produced by secondary particles arising in two of the jets which involve energies of about 10^{14} eV/nucleon have also been analysed. The ratio of the number of secondary interactions produced by neutral to that produced by charged particles is found to be 0.23 ± 0.15. The energies of the particles responsible for 16 of the secondary interactions wer determined. The transverse momentum distribution of the secondar particles, produced in nucleon—nucleus and nucleus—nucleus collisions at $\sim 10^{14}$ eV/nucleon and emitted at small angles (i.e. belonging to the inner cone), is found to be consistent, in the cases studied here, with that observed in nucleon—nucleon collisions at this energy. The observations indicate that nucleon—nucleus and nucleus—nucleus collisions at energies of about $(10^{13}$-$10^{14})$eV/nucleo are, in general, similar to nucleon—nucleon collisions.

5801 STUDIES OF NUCLEON–NUCLEON INTERACTIONS AT ENERGIES OF 2 × 10^{11} eV. N.L.Grigorov, V.V.Guseva, N.A.Dobrotin, K.A.Kotelnikov, V.S.Murzin, S.V.Ryabikov and S.A.Slavatinsky.
Cosmic Ray Conference, Moscow, 1959, English Edition (see Abstr. 7427 of 1960) Vol. I, p. 143-53.

By means of an arrangement (using two cloud chambers and 120 ionization chambers) capable of making direct determinations of the energy of the incident particle (from the total energy release) and of the energies and angles of emission of secondary particles, the characteristics of 16 nucleon–nucleon interactions in the energy range 100-500 BeV were obtained. From the results, it was concluded that a considerable fraction of the showers observed possessed pronounced asymmetry, despite the average symmetry in the divergence of the secondary π-mesons in the c-system. If this conclusion is confirmed the theories that explain the interaction characteristics by assuming the formation of a single excited system by interacting nucleons, will have to be discarded. On the average only about 30% of the energy of the incident nucleon was transmitted to secondary π-mesons generated in the interaction. The majority of its energy is retained by one secondary nucleon and consequently nucleon—nucleon interactions in the high-energy range of hundreds of BeV are characterized by a rather high degree of "elasticity". C.F.Barnaby

5802 ABSORPTION LENGTH VERSUS SIZE OF EXTENSIVE AIR SHOWERS (EAS).
J.Delvaille, F.Kendziorski and K.Greisen.
Cosmic Ray Conference, Moscow, 1959, English Edition (see Abstr. 7427 of 1960) Vol. II, p. 79-83.

The results are given of experiments performed to establish the value of the absorption length of air showers. Two methods were used-based on the barometric effect and the zenith angle dependence of the showers. The value of the absorption length obtained was 141 ± 12 g/cm^2. The mean value of the number of particles in the 259 showers analysed was 2.7 × 10^7. The value obtained was higher than that obtained by other workers and the discrepancy is discussed. C.F.Barnab

5803 OBSERVATION OF THE SUPPRESSION EFFECT ON BREMSSTRAHLUNG.
P.H.Fowler, D.H.Perkins and K.Pinkau.
Cosmic Ray Conference, Moscow, 1959, English Edition (see Abstr. 7427 of 1960) Vol. II, p. 294-5.

For the detection of the suppression effect predicted by Landau and Pomeranchuk (Abstr. 5696 of 1954) it is necessary to measure the radiation of a large number of high energ electrons in order to exclude fluctuations. As the most rapid metho it was decided to measure the distance between the primary pair of a photon-initiated high-energy cascade and its first daughter pair. The distribution obtained for the high-energy cascades is not shifte towards the origin compared with the low-energy cascades, as woul be expected from Bethe—Heitler theory. The results for low-energ showers agree well with the theory of Migdal (Abstr. 462 of 1957). C.F.Barnab

5804 **ANGULAR DISTRIBUTION OF MESON SHOWERS PRODUCED BY HEAVY ($Z > 2$) COSMIC-RAY PRIMARIES.**
M.G.Barbetta, C.Depietri, G.Lovera and R.P.Fedeli.
Atti Semin. Mat. Fis. Univ. Modena (Italy), Vol. 9, 156-61 (1959-60). In Italian.

Investigated in a set of events produced in nuclear emulsions, with special reference to a large shower of 77 relativistic tracks: for all events $\gamma_c < 7.5$. The results concerning the isotropy agree with the known behaviour of the jets produced by singly-charged or neutral particles, for $\gamma_c < 7.5$.

5805 **STUDIES ON EXTENSIVE AIR SHOWERS. I. SEA LEVEL OBSERVATIONS ON THE VARIATION WITH SHOWER SIZE OF THE TOTAL NUMBER OF NUCLEAR-INTERACTING PARTICLES IN SHOWERS OF (10^4 - 2.5×10^6) PARTICLES.** B.K.Chatterjee, G.T.Murthy, S.Naranan, B.V.Sreekantan and M.V.Srinivasa Rao.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1148-56 (Dec. 16, 1960).

An experiment carried out at sea level on the lateral distribution of nuclear-interacting particles in air showers and the variation of their number with the size of the showers, is described; the showers recorded ranged in size from 10^4 to 2.5×10^6 particles. The results indicate that the number of nuclear-interacting particles is proportional to $N_e^{0.45 \pm 0.05}$ for showers of size N_e less than about 6×10^5 particles, and the number is proportional to $\sim N_e^{1.2}$ for larger sizes. What has been obtained in this experiment and in similar experiments conducted by other groups (Nicol'sky et al. and Lehane et al.), is the average number of nuclear-interacting particles in a large number of showers of a given size. The possibility that such an average may not be meaningful if large intrinsic fluctuations (other than normal statistical variations) exist, is pointed out.

5806 **INTERPRETATION OF THE EXPERIMENTAL DATA ON THE SPECTRA OF ELECTRON—PHOTON CASCADES WITH ENERGIES $>10^{12}$ eV IN THE UPPER LAYERS OF THE ATMOSPHERE.** S.I.Nikol'skii and Yu.A.Smorodin.
Zh. eksper. teor. Fiz. (USSR), Vol. 39, No. 4(10), 1156 (Oct., 1960). In Russian.

Interactions of particles in the energy range 10^{11}-10^{13} eV at altitudes of 10-12 km are analysed in conjunction with data on extensive air showers. [English translation in: Soviet Physics—JETP (USA), Vol. 12, No. 4, 804-5 (April, 1961)]. P.K.Kabir

CLOUD-CHAMBER STUDY OF HARD COLLISIONS OF COSMIC-RAY MUONS WITH ELECTRONS. See Abstr. 5743

5807 **VARIATIONS OF THE PRIMARY α-RAYS AND THE TOTAL COSMIC RADIATION.** E.Waibel.
Nuovo Cimento (Italy), Vol. 19, No. 3, 482-96 (Feb. 1, 1961). In German.

The primary α-particle intensity and the total cosmic radiation was measured over Northern Germany (cut-off for protons 1.46 GeV, eccentric dipole) with a balloon sonde during a strong Forbush effect on July 16, 1959. The vertical α-particle flux extrapolated to 0 g/cm^2 was found to be (0.0105 ± 0.0007) cm^{-2} sec^{-1} sterad^{-1} if allowance is made for the fragmentation of heavier nuclei. The extrapolated value of the total radiation amounted to (0.081 ± 0.0015) cm^{-2} sec^{-1} sterad^{-1}. On November 3, 1959, the measurement of the α-particles showed an extrapolated vertical flux of (0.0124 ± 0.0025) particles cm^{-2} sec^{-1} sterad^{-1} and the total radiation amounted to (0.1043 ± 0.0042) particles cm^{-2} sec^{-1} sterad^{-1} (cut -off for protons 1.72 GeV). A comparison of the radiation values from 16.7.1959, 3.11.1959 and 24.4.1957 proves a variation of the hard component at high altitudes which is larger by the factor 1.9 ± 0.3 than that of neutrons on ground level at Lindau. For the α-particles this variation factor turned out to be 1.5 ± 0.5. The absolute intensities of both components measured during the three flights fit well the modulation scheme of Ehmert which was adjusted to the absolute intensities published by McDonald obtained by different experimental techniques.

5808 **DIRECT PAIR PRODUCTION BY HIGH ENERGY MUONS.** J.F.Gaebler, W.E.Hazen and A.Z.Hendel.
Nuovo Cimento (Italy), Vol. 19, No. 2, 265-73 (Jan. 16, 1961).

A multiplate cloud-chamber was operated 1032 ft underground to study electromagnetic interactions of fast cosmic-ray muons. 222 electron showers were observed. A histogram was obtained for transferred energies from 30 to 3000 MeV. The showers are primarily due to direct pair production and knock-on processes. The results indicated that there is agreement with knock-on theory but that the direct pair production cross-section is about $\frac{1}{2}$ that predicted by the Murota—Ueda—Tanaka theory.

5809 **MULTIPLE GEIGER COUNTER COINCIDENCES DUE TO GAMMA RADIATION.** J.C.Barton and E.G.Michaelis.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 377-84 (Feb., 1961).

Triple coincidences produced in Geiger counters by single gamma-rays were found to contribute to the rate of genuine coincidences in unscreened cosmic-ray telescopes at great depths below ground. The effect was examined by a separate anti-coincidence experiment and was shown to be compatible with the hypothesis of successive Compton scatters of single gamma-ray quantum in the three counters.

NUCLEUS

5810 **COULOMB ENERGIES OF MIRROR NUCLEI.** S.Sengupta.
Nuclear Phys. (Internat.), Vol. 21, No. 4, 542-54 (Dec. (3), 1960).

A semiclassical expression for Coulomb energies of the mirror nuclei is derived. The exchange part in the above expression is derived on a statistical model which gives in addition to the usual term, a pairing effect of magnitude 0.33. Inconsistencies in some of the earlier expressions are pointed out. The radius parameter r_0 from this formula agrees very well the the electron-scattering values. A more detailed calculation of the Coulomb energies in LS-coupling shell model with constant values of the parameters within a shell gives least-squares fit with an r.m.s. deviation of nearly 4% in both p and d—s shells. The least-squares fit parameters are not satisfactorily reproduced by the harmonic-oscillator wave-function. The variation of the harmonic-oscillator strength parameter $\alpha = \sqrt{\omega M/\hbar}$ within p and d—s shell is studied. A comparison of the r.m.s. radius from Coulomb energies and electron scattering shows a discrepancy of about 8% in case of Be^9. The vanishing of the second difference of Coulomb energy and its negative value at a shell crossing are found to agree with the detailed shell-model calculation.

5811 **ON THE HARD CORE IN NUCLEAR FORCES.** J.K.Perring and R.J.N.Phillips.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 153-7 (Feb., 1961).

It has been argued that static hard-core potentials cannot match observed $^1S_0$ scattering in certain respects. Counter-examples are presented.

5812 **COMPETITION BETWEEN THE PAIRING FORCE AND THE SPIN—ORBIT FORCE IN V^{51}.** M.Umezawa.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 296-304 (Feb., 1961).

The effect of a pairing force on configuration mixing of spin—orbit partners is estimated. It is found that the effect is comparatively large near closure of the j—j subshells, and detailed results are obtained for the ground state of V^{51}. It is shown that the calculated magnetic moment of V^{51} is considerably improved as compared with the pure j—j pairing result, but the M1 transition from the first excited state to this ground state still remains forbidden.

5813 **IMAGINARY PART OF THE OPTICAL MODEL POTENTIAL IN NUCLEAR MATTER.**
J.Sawicki and S.A.Moszkowski.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 456-61 (Dec. (1), 1960).

The imaginary part of the optical-model potential in nuclear matter was calculated for various values of the energy, assuming Gammel—Thaler nucleon—nucleon interactions. The calculations were made using the separation method in which the interaction is separated into a short-range and long-range part, the former giving zero phase shift. To a good approximation, only the long-range component contributes to the imaginary part of the optical potential.

5814 **THE HIGH ENERGY OPTICAL MODEL AND NUCLEAR FORCES.** J.Dąbrowski and J.Sawicki.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 318-35 (Jan., 1961).

An iteration procedure is discussed for the integral equation relating the t-matrix for two nucleons in the medium to the free nucleon—nucleon t-matrix. The real and imaginary parts of the medium and high-energy optical model potential are discussed from the point of view of this procedure. Numerical results are obtained for the Gammel—Thaler and Signell—Marshak potentials.

5815 CONVERGENCE OF THE CLUSTER EXPANSION FOR THE OPTICAL MODEL POTENTIAL. P.B.Jones.

Nuclear Phys. (Internat.), Vol. 23, No. 2, 349-52 (Feb., 1961).

The convergence of the cluster expansion for the optical model potential is examined, at low energies, by comparison of the series with the potential given by a closed form. The problem of antisymmetrization is not considered.

5816 A METHOD FOR THE ELIMINATION OF SPURIOUS STATES IN THE NUCLEAR HARMONIC OSCILLATOR SHELL MODEL. B.J.Verhaar.

Nuclear Phys. (Internat.), Vol. 21, No. 3, 508-25 (Dec. (1), 1960).

A group-theoretical method is used for a classification of the nuclear eigenstates in the harmonic-oscillator shell model. This classification turns out to be intimately connected with the distinction between good and spurious states. In fact it provides a procedure for the elimination of spurious states. The method makes use of the invariance properties of the system Hamiltonian for several groups of transformations. In particular a group U_3 formerly used for the study of collective rotational effects in the nuclear shell model is of importance. This group is related to the degeneracy of the three-dimensional isotropic harmonic oscillator states. Some special examples, illustrating the method, are given.

CLASSIFICATION OF SHELL MODEL STATES. See Abstr. 5834.

SHELL-MODEL ANALYSIS OF CALCIUM ISOTOPES. See Abstr. 5839

5817 GEOMETRICAL REPRESENTATION OF NUCLEAR PROPERTIES. M.Biener and K.Bleuler.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 589-97 (Feb., 1961).

Experimental nuclear data are represented with the help of a geometrical method, which allows a comprehensive survey of nuclear properties and a more direct comparison with theoretical results. The separation energies (for protons and neutrons), defined in a suitable way, are considered first. These values (for all nuclei so far measured with sufficient accuracy) are then represented by two surfaces in three-dimensional space, which are projected in a convenient manner. Some striking features of the general behaviour of these surfaces are observed: (a) well-pronounced shell-structure effects in the middle part of the periodic table (energy steps after the closing of each shell), (b) a typical discontinuity for N = 90 corresponding to the well-known sudden deformation of nuclear shape, (c) effects of complex structure for lighter elements. With the help of these diagrams a method is given for the representation of single-particle states of odd-mass nuclei. This work represents the continuation of two earlier publications (Abstr. 6384 of 1955; 8775 of 1957).

5818 ALPHA—DEUTERON MODEL OF THE Li^6 NUCLEUS. T.I.Kopaleishvili, I.Sh.Vashakidze, V.I.Mamasakhlisov and G.A.Chilashvili.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 430-8 (March, 1961).

The stability conditions are investigated for a system of three protons and three neutrons creating subsystems with four or more nucleons in the form of an α-particle and a deuteron respectively. It is shown that the 3.87 MeV level of the nucleus of Li^6 can be obtained via the transition of a deuteron in the nucleus from a triplet into a singlet state.

5819 THE SPIN OF THE F^{20} GROUND STATE. E.Freiberg and V.Soergel.

Z. Phys. (Germany), Vol. 162, No. 1, 114-18 (1961). In German.

Determined by means of a circular-polarization correlation measurement on the β—γ cascade of F^{20}. The experimental result gives spin 2 for the ground state. Within the statistical error of the experiment, the β-decay of F^{20} has pure Gamow—Teller interaction.

5820 THE NUCLEAR SPIN OF INDIUM-115 m. H.J.King, J.A.Cameron, H.K.Eastwood and R.G.Summers-Gill.

Canad. J. Phys., Vol. 39, No. 1, 230-1 (Jan., 1961).

The nuclear spin of the 4.5 hr metastable state of In^{115} was measured by the atomic beam magnetic resonance method. In^{115m} was produced by neutron irradiation of cadmium foil in a reactor and subsequently separated chemically. Detection of In^{115m} in the beam was achieved by deposition on buttons at the exit slit of the magnet system and scintillation counting of the 335 keV γ-rays from the de-excitation of the metastable level. The result, $I = \frac{1}{2}$, agrees with the shell model assignment in which the metastable state is formed when the hole in the $g_{9/2}$ proton shell (giving the ground state) is filled to leave a hole in the $p_{1/2}$ shell instead.

R.E.Mead

5821 THE GROUND STATE SPIN OF $^{212}_{84}Po$. F.Demichelis.

Nuovo Cimento (Italy), Vol. 19, No. 4, 642-52 (Feb. 16, 1961).

The angular correlation between the β transitions (energy 2.27 MeV) from the ground state of Bi^{212} to the ground state of Po^{212} and the α-particles (energy 8.776 MeV) from the ground state of Po^{212} to the ground state of Pb^{208}, and the angular correlation between the γ-rays (energy 0.727 MeV) from the first excited state to the ground state of Po^{212} and the above α-particles were measured. The very short lifetime of Po^{212} made these measurements possible. Isotropic correlations in opposition to previous experimental result were found. The results are in agreement with the J = 0+ assignment to the ground state of the even—even nucleus Po^{212}.

5822 EFFECTIVE MOMENTS IN K^{39} AND K^{40}. A.De-Shalit.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 677-88 (Feb., 1961).

It is pointed out that by comparing magnetic moments of levels belonging to the same nucleon configuration in an odd-odd nucleus, or M1 transitions between such levels, an important information on the effective moments of found nucleons can be obtained. This analysis is carried out for K^{40} and the results agree very well with the magnetic moment of K^{39}. An attempt is made to include the effects of configuration mixing in K^{40}, induced by the residual proton—neutron interaction. A δ-type interaction which reproduces the spectrum of Cl^{38} is assumed. The resulting agreement is considerably deteriorated, indicating that such an admixture of configurations is probably negligible in K^{40}. Further experiments are suggested to check the validity of the concept of an effective moment.

OPTICAL HYPERFINE STRUCTURE AND NUCLEAR MOMENTS OF PROMETHIUM 147. See Abstr. 5971

5823 ZEEMAN SPLITTING PARAMETERS OF NUCLEAR QUADRUPOLE SPECTRA FOR SPIN 5/2.

N.Inoue.

J. Sci. Hiroshima Univ. A (Japan), Vol. 24, No. 1, 7-11 (July, 1960

Numerical values for Zeeman splitting parameters of the pure quadrupole spectrum are given for a hundred values of asymmetry parameter for spin 5/2.

5824 INELASTIC ELECTRON SCATTERING AND NUCLEAR COMPRESSIBILITY. L.J.Tassie.

Nuovo Cimento (Italy), Vol. 18, No. 3, 525-31 (Nov. 1, 1960).

The form factors for the electron excitation of vibrational and rotational collective nuclear transitions are obtained assuming the nucleus is incompressible, and compared with the experimental an theoretical results of Helm (1956). The inelastic scattering of hig energy electrons can be used to investigate nuclear compressibilit

5825 NUCLEAR OCTUPOLE DEFORMATION AND THE MECHANISM OF FISSION. S.A.E.Johansson.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 529-52 (Feb., 1961).

The stability of nuclei against an octupole deformation is calculated. It is found that the interaction of levels of opposite parity makes the nuclei in certain regions very soft to octupole deformation. The negative-parity collective states in heavy nuclei and in the rare-earth region can be interpreted as octupole vibrations. The predicted A-dependence of the energy of these states agrees with experimental data. For very elongated shapes, which are of interest in fission, it is found that stable octupole deformati occurs. The potential surface of the fission barrier will therefore possess two asymmetric valleys. There is a linear relationship between the mass ratio of the fission fragments and the degree of octupole deformation at the saddle point. The occurrence of symmetric fission in the lighter elements is explained. The influence the octupole deformation on the fission barrier also provides a basis for understanding the variation in fission threshold. The experimental data agree with the calculated values. The peak-to-valley ratio in the mass distribution is calculated, with the assump tion of statistical equilibrium at the saddle point. Good agreement is found for excitation energies below 10 MeV. For higher energi a symmetric component appears which rises with increasing ener

5826 THE MOMENT OF INERTIA OF ROTATING NUCLEI.

A.Katz and J.Blatt.

Nuclear Phys. (Internat.), Vol. 23, No. 4, 612-29 (March, 1961).

A method developed by one of the authors (Blatt, 1960) for superconductivity and the Meissner effect is applied to the calculation of the rotational moment of inertia of superfluid systems. It is checked that the correct mass is obtained in an analogue translational problem. The expressions for the moment of inertia are equivalent to those of Migdal (Abstr. 4011 of 1960).

NUCLEAR POLARIZATION PRODUCED BY CAPTURE OF POLARIZED THERMAL NEUTRONS. See Abstr. 5923

5827 ABSENCE OF DOPPLER SHIFT FOR GAMMA RAY SOURCE AND DETECTOR ON SAME CIRCULAR ORBIT.

D.C.Champeney and P.B.Moon.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 350-2 (Feb., 1961).

An experiment is described showing that for a source and absorber of Fe^{57} placed at opposite ends of a rotor the Mössbauer absorption is unaffected by rotation. This is contrary to the situation with the source at the centre when relativistic effects cause a frequency shift between source and absorber.

5828 NUCLEAR RESONANT SCATTERING WITHOUT RECOIL (THE MÖSSBAUER EFFECT). W.E.Burcham.

Sci. Progr. (GB), Vol. 48, 630-55 (Oct., 1960).

An account is given of the simpler experimental features and of the first applications of the Mössbauer effect. A brief summary of certain results of the semi-classical theory of radiation is included and the conditions necessary for the observation of nuclear resonant scattering are outlined. The early experiments of Moon are reviewed and the recent work of Mössbauer is described.

E.A.Sanderson

5829 RECOILLESS EMISSION AND ABSORPTION OF 26 keV γ-RAY OF ^{161}Dy.

S.Jha, R.K.Gupta, H.G.Devare, G.C.Pramila and R.S.Raghavan.

Nuovo Cimento (Italy), Vol. 19, No. 4, 682-6 (Feb. 16, 1961).

Recoilless emission and resonance absorption of the 26 keV γ-ray emitted by the β-decay of Tb^{161} were observed. The existence of the first excited state of Dy^{161} at 26 keV is thus confirmed. From the measurement of the transmission of this γ-ray through various thickness of the Dy_2O_3 absorber, the percentages of recoilless emission and recoilless absorption are estimated to be $(10 \pm 2)\%$ and $(6.5 \pm 2)\%$ respectively. From the curve showing the change in the transmission as a function of the relative velocity of the source and the absorber, the width of the 26 keV state (for an absorber thickness of 19.65 mg/cm^2) was found to be about 1.04×10^{-6} eV which is about 70 times what is expected from the measured half-life of this state.

5830 MÖSSBAUER EFFECT WITH Ni^{61}.

F.E.Obenshain and H.H.F.Wegener.

Phys. Rev. (USA), Vol. 121, No. 5, 1344-9 (March 1, 1961).

The Mössbauer effect was observed in Ni^{61}. The Ni^{61*} was obtained by

$$Ni^{64}(p,\alpha)Co^{61} \xrightarrow{\beta^-(99 \text{ min})} Ni^{61*},$$

giving a nickel Mössbauer nucleus in a Ni^{64} host lattice. The magnitude of the effect at $T = 80^\circ K$ is about 4% for a 400 mg cm^{-2} absorber foil (natural nickel). From the thickness dependence the authors obtain $f_{source} = f_{abs} = (9 \pm 1)\%$ for the Debye—Waller factor at $T = 80^\circ K$. The temperature dependence yields a Debye temperature varying between 413° and 437°. The velocity dependence has a half-width of 1.65 mm sec^{-1}. The spectrum deviates from the Lorentz shape expected for a single line. A recent electronic determination of the lifetime of this 71 keV state indicates a natural half-width of 0.37 mm sec^{-1}. The increased half-width and shape of the spectrum observed in this experiment may be understood in terms of a magnetic hyperfine splitting. The moment of the ground state is known. The internal field H and the magnetic moment μ_e of the first excited state are unknown. An analysis of the data gives a connection between the two quantities, $\mu_e(H)$.

5831 A THERMAL RED SHIFT OF THE RECOILLESS γ-EMISSION OF $^{119}Sn^m$.

A.J.F.Boyle, D.St.P.Bunbury, C.Edwards and H.E.Hall.

Proc. Phys. Soc. (GB), Vol. 76, Pt 1, 165-7 (July, 1960).

The 24 keV Mössbauer γ-emission from Sn^{119m} was used to determine the temperature dependence of the thermal red shift. Experiment and theory are found to be in quantitative agreement within the statistical accuracy. Results show that this effect may be very important in measurements of the gravitational red shift, for which Zn^{67} at $4^\circ K$ is apparently most suitable. E.A.Sanderson

5832 MESIC DECAYS OF HYPERNUCLEI FROM K$^-$-CAPTURE. II. BRANCHING RATIOS IN THE CHARGED MESIC DECAY MODES OF $^3H_\Lambda$, $^4H_\Lambda$, $^4He_\Lambda$ AND $^5He_\Lambda$.

R.G.Ammar, R.Levi Setti, W.E.Slater, S.Limentani, P.E.Schlein and P.H.Steinberg.

Nuovo Cimento (Italy), Vol. 19, No. 1, 20-35 (Jan. 1, 1961).

For Pt I, see Abstr. 13154 of 1960. Branching ratios in the charged mesic decay modes of hyperfragments with charge $Z \leq 2$ and mass number $A \leq 5$ are presented, based on a total of 162 events. Such relative frequencies are relevant in discussing the consequences of charge independence, the $\Delta T = \frac{1}{2}$ rule as applied to hypernuclei, and the spin dependence of the Λ–nucleon interaction. In particular, the ratio R_4 of (π^--recoil) with respect to all π^- decays for $_\Lambda H^4$ was found to be $R_4 = 0.67^{+0.06}_{-0.06}$, where the errors represent statistical uncertainties only. Comparing this with the curves of R versus (p/s) calculated by Dalitz and Liu on the two assumptions (J = 0, 1) regarding the spin of $_\Lambda H^4$, concluded that the value J = 0 is more probable, as previously suggested on the basis of the preliminary data. If this spin assignment is accepted, following Dalitz and Liu, one may infer that for ratio of p- to s-wave amplitude in the charged decay of the free Λ; $0.45 \leq p/s \leq 1.4$. Finally, although they should have the same general configuration as the π^- events, no examples of decays involving either the emission of a π^+ or a charged lepton were identified in the sample.

5833 NUCLEAR MAGNETIC ABSORPTION CURVE OF A SYSTEM OF THREE NUCLEONS FORMING AN EQUILATERAL TRIANGLE. A.Corciovei.

Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 3, 295-309 (1957). In Roumanian.

A study of nuclear magnetic resonance in a system of three nucleons positioned at the apexes of an equilateral triangle of side r. The stationary states in a constant magnetic field are studied. It is shown that the perturbed energy levels, taking into account a second order dipole perturbation as well as a first order exchange perturbation, depend only on universal constants, the value of the magnetic field, the angle between the normal to the plane of the triangle and the field direction, and on the separation r. The same situation obtains for the transition probabilities. Finally, the absorption curve for an ensemble of independent systems of three nucleons, isotropically oriented in space, is studied. D.W.L.Sprung

Energy Levels

5834 SYMPLECTIC INVARIANTS AND FLOWERS' CLASSIFICATION OF SHELL MODEL STATES.

K.Helmers.

Nuclear Phys. (Internat.), Vol. 23, No. 4, 594-611 (March, 1961).

Flowers has given a classification of shell-model states in j—j coupling for a fixed number of nucleons in a shell with respect to a symplectic group. In this paper the relation between these classifications for the various nucleon numbers is studied and is found to be governed by another symplectic group, The transformations of which in general change the nucleon number.

5835 SPECTRA OF ODD NUCLEI.

A.De-Shalit and J.D.Walecka.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 184-201 (Jan., 1961).

A general discussion of the spectra of odd nuclei is presented. For this purpose it was found useful to develop a new method for the calculation of energy levels. An explicit expression is derived for the distribution of the relative angle of the two particles, properly weighted according to the spin-dependence of the interaction. With the help of these expressions the general structure of spectra of odd nuclei can be more clearly seen. In particular the modified Nordheim rules are seen to hold quite generally, and it is found that for configurations containing a half-filled shell the lowest state has an even or odd J according to whether its parity is odd or even.

5836 POSITIVE-PARITY STATES IN MASS-13 NUCLEI.

D.Kurath and R.D.Lawson.

Nuclear Phys. (Internat.), Vol. 23, No. 1, 5-22 (Feb., 1961).

The strength of coupling between the positive-parity nucleon and the C^{12} core is investigated. Strong coupling, as implied by using the Nilsson model to generate wave-functions, contradicts experiment. A reasonable picture arises from weak coupling with a strength consistent with that derivable from summing the two-body interaction integrals between the positive-parity nucleon and the core.

ENERGY LEVELS OF SPHERICAL NUCLEI, FROM TWO-PARTICLE GREEN'S FUNCTIONS. See Abstr. 5234

5837 ON THE 5.16 MeV AND 7.56 MeV STATES OF B^{10}.
W.W.True and E.K.Warburton.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 426-33 (Feb., 1961).

The methods developed by Talmi and co-workers are used to calculate the binding energies of the two B^{10} levels formed by coupling $2s_{1/2}{}^2$ to the Be^8 ground state. The calculated energies are found to be in excellent agreement with those of the B^{10} 5.16 and 7.65 MeV levels for which the most probable spin-parity and isobaric-spin assignments are $J^\pi = 1^+$, T = 0 and $J^\pi = 0^+$, T = 1, respectively. The strong γ-transition connecting these levels is also consistent with the proposed identification with double-particle excitation into the 2s—1d shell. The excitation energies of $2s_{1/2}{}^n$ levels in Be^{10}, B^{11} and C^{12} are also calculated assuming that the Be^8 ground state forms an inert core.

5838 ANGULAR CORRELATION IN Be^9(p, γ)B^{10} AND THE STATES OF B^{10} AT 7.56 AND 5.16 MeV.
N.W.Tanner and S.S.Hanna.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 319-26 (Feb., 1961).

A measurement was made of the angular correlation of γ-rays from the 7.56 MeV state of B^{10} (the 1.084 MeV resonance of Be^9(p, γ)B^{10}). An asymmetry of 9% was found which seems to settle the spin and parity of the 7.56 MeV state as being $J^\pi = 0^+$. The consequence of this definite assignment is that the 5.16 MeV state cannot be the second T = 1 state of B^{10}. It is suggested that the state at 4.77 MeV is the T = 1 state despite the shift of 0.33 MeV from the expected position. A tentative assignment of $J^\pi = 1^+$, T = 0, is made to the 5.16 MeV state.

5839 SHELL-MODEL ANALYSIS OF CALCIUM ISOTOPES.
H.E.Mitler.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 200-44 (Feb., 1961).

An intermediate shell-model calculation is made for Ca^{42} and Ca^{43}. The effective two-body (static) internucleon potential, acting among the neutrons outside the Ca^{40} core, is phenomenologically obtained by fitting the known energy levels of 42 and 43. The fit to eight levels is fair, the r.m.s. deviation being 124 keV. The potential is found to differ strongly from that expected from nucleon—nucleon scattering experiments: it is long-, rather than short-ranged, has a weak repulsive (rather than attractive) triplet odd part, and a strong, attractive (rather than weak, repulsive) tensor part. The fit to the energy levels is nevertheless better than what has been obtained heretofore. A comparison of the calculated electromagnetic transition probabilities indicates a considerable amount of surface-particle coupling, indicating a strong admixture of one of the core states. A theorem is derived which facilitates computation of tensor force matrix elements in j—j coupling.

THE 9.63 MeV STATE OF C^{12}. See Abstr. 5910

5840 NEGATIVE PARITY LEVELS IN THE EVEN-EVEN NUCLEUS Dy^{160}. G.T.Ewan, R.L.Graham and J.S.Geiger.
Nuclear Phys. (Internat.), Vol. 22, No. 4, 610-28 (Feb., 1961).

The conversion-electron spectrum of Tb^{160} was studied in the Chalk River air-cored $\pi\sqrt{2}\beta$-ray spectrometer at resolution settings of 0.04% to 0.1%. Gamma-conversion electron coincidence experiments were made to establish the positions of the levels in Dy^{160}. The level scheme based on the present results is 0(0+), 86.7 (2+), 283.6 (4+), 965.8 (2+), 1048.8 (3+), 1264.4 (2−), 1286.5 (3−), 1358.2 (2−), and 1398.5 keV (3−). This is similar to that of Nathan (Abstr. 4272 of 1958) in the positive parity levels but differs in the negative parity levels. Particular attention was paid to determining the intensities of weak transitions in the decay scheme. The relative quantum probabilities were deduced from the conversion-line measurements using Sliv's theoretical conversion coefficients. The agreement between the observed transition probabilities from the positive parity levels and the theoretical predictions of the unified model is greatly improved if a small amount of K = 0 band is assumed mixed in the K = 2 gamma-vibrational band. The relative transition probabilities from the negative parity levels are not consistent with K being a good quantum number in discussing these levels. The possibility of interaction between the negative parity level is briefly discussed.

5841 THE 0$^+$, T = 1 LEVEL IN ^{18}F.
D.Eccleshall and M.J.L.Yates.
Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 93-6 (Jan., 1961).

γ-rays were observed from F^{18} states formed by positron deca of Ne^{18}. A 1.04 MeV γ-ray is present in the spectrum, suggesting that the 1.04 MeV level in F^{18} is the 0$^+$, T = 1 analogue of the Ne^{18} ground state. This is in agreement with the assignment of Hinds a Middleton (Abstr. 5757 of 1960). L.L.Gree

LEVELS IN Gd^{156}. See Abstr. 5877

LEVELS OF Li^6. See Abstr. 5893

LIFETIME OF THE 3.56 MeV LEVEL OF Li^6. See Abstr. 5

5842 INVESTIGATION OF γ-RAYS FROM Mg^{24}, Mg^{25}, Mg^{26} ISOTOPES BOMBARDED WITH Po α-PARTICLES.
E.Csongor.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 107-15 (Feb., 1961).

Electromagnetically separated Mg^{24}, Mg^{25}, Mg^{26} isotopes were bombarded with Po α-particles. In the case of Mg^{25} and Mg^{26} the excitation function of γ-radiation from the nuclear processes was measured with a thin target. In the case of the Mg^{25} target, resonances were found at α-energies of 3.58, 4.33, 4.47, 4.61, 4.80, 4.9 and 5.09 MeV; in the case of Mg^{26} target, at α-energies of 4.56 an 5.01 MeV. From these data seven highly excited states of the Si^{29} compound nucleus and two of the Si^{30} nucleus were determined. T origin of γ-radiation was deduced from the observed spectra of γ-rays. A method for a micro-electrochemical deposition of Mg w developed.

N^{14} LEVELS FROM γ-DECAY. See Abstr. 5867

N^{14} RESONANCE LEVELS. See Abstr. 5935

ENERGY LEVELS IN O^{14} AND Ne^{18}. See Abstr. 5940

Se^{77} LEVELS. See Abstr. 5907

5843 SPECTROSCOPIC CALCULATION OF ENERGY LEVELS OF SOME TIN ISOTOPES. J.B.Sanders.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 305-11 (Feb., 1961).

Energy levels of a series of isotopes of tin are calculated. Configuration mixing is taken into account. A reasonable fit wit the experimental data is obtained and mixing ratios for wave-func are also found.

5844 VIRTUAL LEVELS IN THE VANADIUM ISOTOPES FROM PROTON BOMBARDMENT OF THE TITANIUM ISOTOPES. J.Dubois.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 537-58 (March, 1961).

Electromagnetically separated Ti isotopes were bombarded protons in the 800-1400 keV interval. From the (p, γ) resonances the virtual levels in the V isotopes were determined. Level spac are discussed.

NUCLEAR DECAY
RADIOACTIVITY

5845 A SIMPLE METHOD OF ABSOLUTE BETA COUNTING BY SCINTILLATION TECHNIQUE. M.G.Shahani.
. sci. industr. Res. (India), Vol. 19B, No. 12, 461-4 (Dec., 1960).
A method is described using plastic scintillators. The low-
nergy part of the spectrum for P^{32} is obtained by a linear extra-
olation of the experimental plot of the β-spectrum. Since only one
hotomultiplier is needed, the method is simple and the experiment
an be carried out at room temperature without the additional equip-
ent usually needed for cooling the phototube. The method gives
onsistent results over the working region 600-900 V.

5846 A LOW BACKGROUND BETA COUNTER WITH A PLASTIC SCINTILLATOR ANTICOINCIDENCE SHIELD.
R.Gat(Gutmann) and J. Gilat.
uclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 233-5
ug., 1960).
The counter consists of a central gas-flow proportional counter
rrounded by a large plastic scintillator anticoincidence shield.

5847 GROUNDING OF BETA SOURCES BY AN AUXILIARY ALPHA SOURCE. R.T.Nichols and E.N.Jensen.
ev. sci. Instrum. (USA), Vol. 31, No. 12, 1358 (Dec., 1960).
When β-sources with thin insulating backings are used in β-
pectrometers difficulty is usually experienced due to charging up
f the source. A method previously used to avoid this is that of
ombarding the source with electrons, the discharge being due to
econdary emission. Another method using a subsidiary Po^{210}
-source is described. This source is placed behind the β-source
the spectrometer and prevents its charging by causing loss of
lectrons due to ionization by the α-particles. R.E.Meads

ISOTHERMAL GAMMA CALORIMETER. See Abstr. 5706

5848 EVALUATION OF FUTURE LEVELS OF RADIOACTIVE FALLOUT. K.G.Vohra and U.C.Mishra.
uovo Cimento (Italy), Vol. 18, No. 6, 1076-85 (Dec. 16, 1960).
The evaluations of future levels of Sr^{90} deposition on the ground
ere carried out for three different cases: (1) no more nuclear
eapon tests are carried out after October, 1958; (2) tests continue
be carried out at the same average rate as in the past, and (3)
ests are carried out at the highest rate observed in the past, i.e.
uring the year 1958. These evaluations are for Bombay, India, and
re based on the ground deposition data on 1st October, 1958, and
tratospheric inventories due to injections in the equatorial and
olar regions as given by Libby. For the case (1) the maximum level
f ground deposition will be 28 mC/square mile and this value will
e reached in 1963. The maximum values of ground deposition for
ases (2) and (3) are 152.7 mC/square mile and 438.7 mC/square
ile respectively. The factors relating the ground deposition of
r^{90} to its concentration in human bone are discussed. The estimated
oncentrations of Sr^{90} in human bone are 4.8, 26.5 and 76 $\mu\mu$C Sr^{90}
er gram of bone calcium for cases (1), (2) and (3) respectively.

5849 RADIOCARBON DATING.
W.F.Libby.
cience (USA), Vol. 133, 621-9 (March 3, 1961).
Review article.

5850 THE ROLE OF RADIO-CARBON C^{14} IN THE IONIZATION OF THE AIR OF GROTTOES. G.Atanasiu.
tud. Cercetari Fiz. (Roumania), Vol. 9, No. 3, 313-16 (1958).
Roumanian.
A calculation is made of the ionization of the air in grottoes
roduced by β-radiation from radioactive carbon contained in CO_2
reed during the formation of stalagmites and stalactites.
J.Dutton

5851 THE REDUCED WIDTHS FOR DEUTERON EMISSION, CALCULATED ON THE BASIS OF THE NUCLEAR
HELL MODEL. M.Micu and A.Săndulescu.
tud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 257-76 (1959). In
oumanian.
The emission of deuterons from excited nuclei is described
ith the help of the shell model, and the reduced widths obtained as analytic expressions in the case of N equivalent nucleons outside a closed shell as well as for the case of a single nucleon. Each expression is derived for the two extremes of LS and jj coupling. The results are compared with experiments on the reactions $He^5 \rightarrow H^3 + H^2$ and $Li^5 \rightarrow He^3 + H^2$. S.J St-Lorant

5852 ISOMERIC STATES OF THE SPHERICAL NUCLEI OF Eu^{147}, Eu^{149} AND Eu^{151}.
E.Ye.Berlovich, V.N.Klementyev, L.V.Krasnov, M.K.Nikitin and I.Yursik.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 181-90 (March, 1961).

Half-lives of the $h_{11/2}$ levels of Eu^{147}, Eu^{149} and Eu^{151} were measured and the following respective values were obtained: $T_{1/2} = (7.1 \pm 0.4) \times 10^{-7}$ sec, $T_{1/2} = (2.48 \pm 0.05) \times 10^{-6}$ sec and $T_{1/2} = (5.8 \pm 0.3) \times 10^{-5}$ sec. The M2-type transitions from the $h_{11/2}$ levels proved to be retarded, the degree of retardation increasing with the number of neutrons from 84 to 88. The E3-type transition rates in the nuclei of Eu^{147} and Eu^{149} proved to be close to one-particle evaluations. The results of the present investigation, together with earlier Soviet results (1958-9) contradict the analysis performed by Nilsson (Abstr. 3526 of 1957) and Gottfried (Abstr. 8920 of 1956) on the motion of an odd proton of Eu^{151} in a deformed potential.

5853 ON THE POSSIBILITY OF THE DETECTION OF DOUBLE QUANTUM EMISSION IN ATOMIC NUCLEI, WITH SPECIAL APPLICATION TO THE DECAY OF Xe^{131m}.
T.Alväger and H.Ryde.
Ark. Fys. (Sweden), Vol. 17, Paper 32, 535-51 (1960).

Some possibilities for the observation of double quantum emission from an excited nuclear level are considered. In particular the decay of the isomeric $h_{11/2}$ level in Xe^{131} was experimentally studied with emphasis on this second-order effect. The measurements were performed by observation of the coincidence relations between X-rays and gamma- or X-radiation. A number of processes which can possibly contribute to the results obtained, is discussed in detail. The possibility that double quantum emission was observed remains then as the most probable one. With this assumption it is possible to estimate an experimental value for the ratio between the transition probabilities for double and single quantum emission in the decay of Xe^{131m} to about one part in a thousand.

5854 NEW DELAYED-NEUTRON PRECURSORS.
G.Rudstam, Å.Svanheden and A.C.Pappas.
Nature (GB), Vol. 188, 1178-80 (Dec. 31, 1960).

Describes detection delayed neutron activities from the spallation products of irradiation of thick copper targets. The activities detected had half-lives of 8 sec, 18 sec and one too short to measure. Measurements using neodymium indicated known periods of 6 sec and 20 sec. The new periods have not yet been identified but further experiments are to be carried out.
R.H.Thomas

5855 THE OSCILLOSCOPE METHOD OF MEASURING NUCLEAR HALF-LIVES.
I.Bergström, E.C.O.Bonacalza, A.Jech, M.Perez and P.Thieberger.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 151-72 (Aug., 1960).

It is shown that modern fast oscilloscopes are very simple and powerful tools for measuring nuclear half-lives. The advantages and the limitations of the method are discussed. In order to illustrate the problems which are associated with measurements in different half-life regions, seven half-lives associated with metastable states in the following nuclei were measured: Pb^{205} (4.1msec), Pb^{206} (125 μsec), Ta^{181} (17.5 μsec), Rb^{85} (1.0 μsec), Pb^{204} (302 mμsec), Pb^{203} (55 mμsec) and Ta^{181} (11.0 mμsec). The half-lives measured thus cover a half-life ratio of almost 10^6:1, but it is shown that in favourable cases this ratio might be as large as 10^8:1. Thus the oscilloscope method can be used in the whole region where conventional delayed coincidence technique is applicable. It is significant for the usefulness of the method that when studying half-lives which were reasonably well known and only chosen for the purpose of investigating the oscilloscope method itself, a new half-life was discovered in one of the samples used (Pb^{203}, 55 mμsec). A very great advantage of the oscilloscope is the fact that it can be very easily used as a multi-channel time analyser, by continuously photographing the events on the oscilloscope screen.

5856 LIFETIME OF THE 3.56 MeV LEVEL OF Li^6.
I.Sh.Vashakidze, T.I.Kopaleishvili and G.A.Chilashvili.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 694-5 (March, 1961).

Using the isobaric invariance the lifetime τ of the excited state of Li^6 with the excitation energy of 3.56 MeV is calculated by means of the matrix elements of the β-decay He^6 → Li^6. The calculation yields $\tau \cong 0.8 \times 10^{-17}$ sec, which is roughly $\frac{1}{10}$ of the experimental result.

5857 NOTE ON THE α-PARTICLE ENERGY SPECTRUM IN Li^8 DECAY. G.N.Fowler and T.W.Preist.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 667-71 (March, 1961).

An attempt is made to correlate the asymmetry in the energy distribution of α-particles from Li^8 decay with the asymmetry in the behaviour of the phase shift in the J = 2 state. A phenomenological potential of the Haefner type is used and the nuclear matrix element is evaluated using the mean value theorem. It is found that the two sets of data can only be correlated if the repulsive core is weakened as the energy increases.

ALPHA-DECAY OF Li^8. See Abstr. 5930

5858 LEPTON CONSERVATION AND DOUBLE BETA-DECAY. E.Greuling and R.C.Whitten.
Ann. Phys. (USA), Vol. 11, No. 4, 510-33 (Dec., 1960).

Double beta-decay is investigated without assuming lepton conservation. If the lepton part of the universal V—A current operator is linear in the massless Majorana neutrino field, leptons are conserved. The intermediate state neutrino is completely polarized and may not be reabsorbed to produce a neutrinoless double beta-decay final state. Two slight modifications of the interaction: (1) finite neutrino mass, and/or (2) a deviation from exact equality of the effective V and A lepton currents, result in the creation of an incompletely polarized intermediate state neutrino which may then be reabsorbed. Neutrinoless double beta-decay, in violation of lepton conservation, is then possible. These neutrinoless modes of double deta-decay are computed for several nuclei and are compared with the usual lepton conserving two-neutrino mode. Measureable competition between these decay modes may exist. The abandonment of lepton conservation does not alter significantly any of the predictions of the universal V—A Fermi interaction for all first order beta-processes

5859 MATRIX ELEMENTS IN THE FORBIDDEN BETA DECAY OF Ce^{141}.
D.D.Hoppes, E.Ambler, R.W.Hayward and R.S.Kaeser.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 115-18 (Feb. 1, 1961).

Measurements were made on oriented Ce^{141}. The energy and angular distribution of the β-particles were measured with respect to the nuclear spin orientation. The measurements are used to obtain information on the relative contributions of the various nuclear matrix elements contributing to the beta transitions.

L.L.Green

5860 DECAY OF ^{152}Eu.
P.N.Mukherjee, I.Dutt, A.K.Sen Gupta and R.L.Bhattacharyya.
Physica (Netherlands), Vol. 26, No. 3, 179-90 (March, 1960).

The decay of mass-spectrometrically enriched Eu^{152} was studied using a Siegbahn—Slätis beta-ray spectrometer, a scintillation spectrometer and a gamma—gamma coincidence device. From the analysis of the beta spectrum α_K of the 344 keV gamma radiation was found to be 0.033 ± 0.001. A low energy beta group with an end point at 417 keV was found, and to fit this to the decay scheme it is suggested that there is a 1415 keV level in Gd^{152} which decays entirely by an emission of a 1415 keV gamma-ray. The α_K, K/L and L/M values of the 122 keV gamma-ray in Sm^{152} are compared with the theoretical values of Rose based on finite nuclear size.

ABSOLUTE BETA-ELECTRON LONGITUDINAL POLARIZATION. See Abstr. 5900

5861 ISOTOPIC SPIN ADMIXTURES IN Ge^{66} → Ga^{66} → Zn^{66} β TRANSITIONS. W.P.Alford and J.B.French.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 119 (Feb. 1, 1961).

It is pointed out that the β-transitions Ge^{66} → Ga^{66} proceed via an admixture in its own ground state of the T = 2 level which is the analogue of the Ga^{66} ground. The log ft value of this transition is used to estimate the magnitude for this admixture. Similarly, Ga^{66} decays via an admixture in its ground state of the analogue of the Zn^{66} ground state and the size of this admixture is estimated.

L.L.Green

5862 THE DECAY OF NEPTUNIUM-238.
R.G.Albridge and J.M.Hollander.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 438-49 (Dec. (1), 1960).

A study was made of the energy levels of Pu^{238} which are populated by Np^{238} beta-decay, by an examination of the Np^{238} conversion electron spectrum in high-resolution beta spectrographs. The general features of the level scheme as previously given are unchanged but several new transitions were observed, with energies 119.8, 871, 943, 989 and 1034 keV, and two new levels are postulated at 915 and 1034 keV which accommodate all but the 943 keV transition. A possible assignment of the 943 keV transition to the (0+ , 0) state of the beta vibrational band is discussed. In addition, the weak 885 keV transition from the 2+ state of the gamma-vibrational band to the 4+ state of the ground band was found and its relative intensity determined. Comparisons are made of the experimental relative transition intensities of the three photons depopulating this band with those predicted from the rules of Alaga et al. (1955); only fair agreement is obtained. A discussion is given of the beta-decay branchings and log ft values of Np^{238} decay in terms of the postulated characters of the Pu^{238} states and the measured spin of Np^{238}.

5863 MIXING RATIOS OF 2+ −2+ TRANSITIONS IN EVEN—EVEN NUCLEI IN THE MASS REGION A = 122-128.
I.Asplund, L.G.Strömberg and T.Weidling.
Ark. Fys. (Sweden), Vol. 18, Paper 5, 65-74 (1960).

Angular correlation measurements were carried out on some even—even nuclei in the mass region A = 122-128 in an attem to study the variation of the mixing ratio E2/M1 in 2+ −2+ transitio when a neutron or proton pair is added to the nucleus. The 2+ −2+ transitions discussed in this report have all been found to be of almost pure E2 character. The following nuclei were studied: Te^{12} Te^{126}, Xe^{126}, and Xe^{128}.

5864 ISOMERIC TRANSITIONS IN Pb^{205}.
R.Stockendal.
Ark. Fys. (Sweden), Vol. 17, Paper 33, 553-78 (1960).

From measurements with electromagnetically isotope-separa samples in a double-focusing β-spectrometer, a (26.22 ± 0.01) keV transition if Pb^{205} was identified from its internal L_I, L_{II}, L_{III}, M_I M_{II}, M_{III}, M_{IV}, N_I, N_{III} and O_I conversion lines. The multipolarity was proved to be M2. There is strong evidence that this transition takes place from a 4.0 msec $i_{13/2}$ state of 1013.8 keV to the 987.6 ke state in Pb^{205}, thus causing the latter state to appear metastable, a has earlier been reported. This suggestion is also supported by th identification of a 310.5 keV E3 transition which probably takes pla between the isomeric state and the 703.3 keV state. Furthermore, there is reason to believe that the expected M4 transition to the ground state is seen as part of a radiation of 1014.0 keV observed i the decay of Bi^{205}. The separation between the $i_{13/2}$ and $f_{5/2}$ levels i found to fit well into the systematics of the odd lead isotopes. The electromagnetically separated sources were used also for a conclusive establishment of a 262.8 keV M1 transition in Pb^{205} (cf. the 262.8 keV M1 transition in Pb^{206}). The possibility that this transiti is associated with the first excited state is discussed. Some furthe conversion lines were also studied in the double-focusing spectrometer. In addition, the relative intensities of the KLL Auger lines lead were measured and found to be in fairly good agreement with theoretical, relativistic calculations.

5865 THE EMPIRICAL MATRIX ELEMENT OF THE M4 TRANSITION IN Xe^{135}. T.Alväger.
Ark. Fys. (Sweden), Vol. 17, Paper 31, 521-34 (1960).

The M4 transition in Xe^{135} was investigated by use of electromagnetically isotope separated samples. The measured energy of the transition is 527.4 ± 0.8 keV and the half-life 15.8 ± 0.4 min. The empirical matrix element of the M4 transition is found to be equal, within the experimental errors, to those of the other known M4 isomers in Xe, except Xe^{129m}.

5866 ANALYSIS OF GAMMA—GAMMA POLARIZATION—DIRECTIONAL CORRELATIONS INVOLVING MULTIPOLE MIXTURES. M.B.Martin, R.G.Arns and M.L.Wiedenbeck.
Phys. Rev. (USA), Vol. 121, No. 6, 1732-4 (March 15, 1961).

A method is described for the graphical analysis of the gamma gamma polarization—directional correlation when one or both gamma-rays involve a mixture of dipole and quadrupole radiation. The case in which the polarization of the mixed gamma-ray is bserved is treated in detail.

5867 GROUND-STATE GAMMA-TRANSITIONS FROM STATES AT 10.09 AND 10.24 MeV IN N^{14} AND REINVESTIGATION OF THE 9.17 AND 10.43 MeV GAMMA-RAY DISTRIBUTIONS.

H.J.Rose, F.Riess and W.Trost.

Nuclear Phys., Vol. 21, No. 3, 367-82 (Dec. (1), 1960).

The angular distributions of the ground-state transitions from the N^{14} 9.17 and 10.43 MeV levels were reinvestigated using the reaction $C^{13}(p,\gamma)N^{14}$ at the 1.75 and 3.11 MeV resonances. From the value obtained for the anisotropy of the 9.17 ($J^{\pi} = 2^+$) → 0($J^{\pi} = 1^+$) transition, limits to the quadrupole—dipole mixture are deduced. The 10.43 MeV state is assigned J = 2 using the results of previous investigations. From the measured distribution, limits are set to the quadrupole—dipole mixture in the 10.43 → 0 transition. A strong energy-dependent $\cos\theta$ term is observed in the angular distribution of the ground-state gamma-rays for proton bombarding energies between 2.7 and 3.2 MeV. For this energy range the (p,γ) excitation functions were determined at angles of 0°, 90° and 140° with respect to the proton beam and additional distribution measurements were made in the neighbourhood of the 3.11 MeV resonance. The theoretical fits of these data present evidence that the $\cos\theta$ term arises mainly from interference between the 10.43 MeV level and "non-resonant background" caused by the "long-tailed" 0.55 MeV resonance corresponding to the 8.06 MeV, $J^{\pi} = 1^-$, T = 1 state. In as much as this explanation of the $\cos\theta$ term is likely, the 10.43 MeV level must have even parity. Rather marked variations of the strength of the $\cos\theta$ term at proton bombarding energies of 2.75 and 2.90 MeV show the presence of levels at 10.09 and 10.24 MeV excitation energy in N^{14} which decay extremely weakly to the ground state. The 10.09 MeV state is also clearly observed in the excitation functions. Estimates of the total widths and gamma-widths of both these states are obtained from the excitation functions. Gamma-rays from states at 10.09 and 10.24 MeV have not been reported previously.

5868 ON THE DECAY OF ^{129}Cs.

S.Jha, H.G.Devare and R.M.Singru.

Nuovo Cimento (Italy), Vol. 18, No. 6, 1109-15 (Dec. 16, 1960).

The radiations from the decay of Cs^{129} were investigated by β-ray spectrometer and coincidence scintillation spectrometer techniques. New γ-rays of 790 and 920 keV were detected. The conversion coefficients of the γ-rays and percentages of the electron captures to different excited states of Xe^{129} are estimated. A level scheme of Xe^{129} and the possible spin and parity assignments to different levels are suggested.

5869 A MEASUREMENT OF THE DECAY OF ^{181}W.

W.E.Kreger and R.L.Lynn.

Nuovo Cimento (Italy), Vol. 18, No. 5, 829-36 (Dec. 1, 1960).

The half-life of the 59.2 keV X-radiation following the decay by orbital electron capture of W^{181} was measured and found to be (126.2 ± 3.2) days. The measurement was made using a source electromagnetically enriched in W^{180} before neutron irradiation. To ensure that the possible low-energy radiation from W^{185} was not influencing the measurements, a calculation was made to show that this contamination was not a problem. An additional measurement on a natural tungsten source confirmed the results of the calculation.

5870 ON THE DECAY OF BARIUM 129.

E.Arbman and I.B.Haller.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 341-52 (Feb., 1961).

The internal-conversion and positron spectra of Ba^{129} were studied with a double-focusing beta-ray spectrometer. Positrons of energies 1425 ± 15 keV, 1243 ± 35 keV and 975 ± 60 keV with relative intensities 780, 240 and 60, respectively, were found. More than 60 transitions are identified from internal-conversion lines. The decay of positrons and a large number of conversion lines was followed in the spectrometer. A half-life of 2.61 ± 0.02 hours was found for the positrons, and half-lives ranging from 2.00 ± 0.10 to 2.37 ± 0.08 hours were measured for various conversion lines. About 6% of Ba^{129} was found to decay by positrons. The observations are interpreted as a consequence of isomerism in Ba^{129}.

5871 INTERNAL AND EXTERNAL CONVERSION STUDIES ON THE DECAY OF Bi^{203} AND Bi^{204}.

R.Stockendal.

Ark. Fys. (Sweden), Vol. 17, Paper 34, 579-96 (1960).

The internal K-conversion coefficients of 7 transitions following he decay of Bi^{203} (including the 279.1 keV transition in Tl^{203}) and 5 ransitions from the decay of Bi^{204} were determined absolutely by the method of comparing internal and external conversion lines measured in a double-focusing spectrometer. The multipolarity assignments based on these values are, in cases where a comparison is possible, in agreement with the assignments suggested from the measured internal conversion ratios or other data. Complementary measurements of energies and intensities of low-energy conversion lines in Pb^{203} were carried out in the double-focusing spectrometer. The level scheme of Pb^{203} is discussed. The half-lives of Bi^{203} and Bi^{204} were remeasured and found to be (11.76 ± 0.05) hr and (11.22 ± 0.10) hr, respectively.

5872 INTERNAL CONVERSION OF ^{141}Ce.

J.R.Cook.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 346-9 (Feb., 1961).

The K-conversion coefficient of the 141 keV gamma-ray of Ce^{141} was measured by a scintillation spectrometer as 0.405 ± 0.01. This indicates that the radiation is probably electric quadrupole.

5873 DIFFERENCES IN NATURAL WIDTHS OF CONVERSION LINES.

J.H.Dijkstra and C.De Vries.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 524-31 (March, 1961).

A folding procedure was applied to K- and L-conversion line pairs due to gamma-ray transitions in Hg and Bi isotopes, measured with an iron-free double focusing beta-ray spectrometer. Apart from yielding an accurate determination of the $B\rho$-ratio of corresponding K- and L-lines this procedure indicated the difference of the atomic level widths to be 49 ± 5 eV in Bi and 54 ± 5 eV in Hg, in fair agreement with X-ray data.

5874 CONCERNING THE DECAY OF Se^{75}.

E.P.Grigoriev and A.V. Zolotavin.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 689-91 (Feb., 1961).

No lines corresponding to the 188 keV and 203 keV were detected in the internal and external conversion spectrum of Se^{75}.

5875 ANGULAR DISTRIBUTIONS OF PHOTOELECTRONS EJECTED FROM URANIUM BY 1.118 MeV GAMMA RAYS.

S.Hultberg, T.O'Connor and J.H.Hamilton.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 306-15 (Jan., 1961).

Reports study of the longitudinal angular distributions of photoelectrons ejected from the K-, L-, and M + N + ...-shells of uranium at a gamma-ray energy of 1118 keV. The application of these angular functions to the calculation of the photoelectric correction factor f is discussed. It is important to obtain f at an energy such as 1.118 MeV to increase the accuracy, around 1 MeV, in the curve of f v. energy. A smooth-curve relationship, in a log—log diagram, is found between the gamma-ray energy $h\nu$ and the angle θ_m of maximum photoelectric cross-section. It is pointed out that the Swedish computer BESK now undertakes calculations of f at four gamma-ray energies: 412, 662, 1118 and 1332 keV (assuming rectangular symmetry and taking source into account). This new calculation increases the accuracy of f values such that the overall accuracy in f between 400 and 1400 keV is now considered to be of the order of 1%.

GAMMA RAYS CORRESPONDING TO A DIPOLE OR A HIGH QUADRUPOLE EXCITATION OF CARBON 12 BY 150 MeV PROTONS. See Abstr. 5906

5876 LIFETIMES OF THE 668 keV AND 961 keV EXCITED STATES IN Cu^{63}.

T.Rothem, F.R.Metzger and C.P.Swann

Nuclear Phys. (Internat.), Vol. 22, No. 3, 505-12 (Feb., 1961).

The 668 keV and 961 keV levels of Cu^{63} were studied by the resonance scattering method. The levels were excited by the gamma radiations from gaseous and from liquid sources of Zn^{63}, and both the resonance effect and the angular distribution of the scattered radiations were measured. Fitting the data to a distribution of the form $W(\theta) = 1 + A_2P_2(\cos\theta)$ yielded the values −0.03 ± 0.7 and 0.8 ± 0.2 for A_2 in the case of the 668 keV and 961 keV lines, respectively. Assuming spin $\frac{1}{2}$ for the 668 keV level, its mean life was measured to be $(3.1 \pm 0.3)10^{-13}$ sec. The mean life of the 961 keV level was found to be $(9 \pm 1.5)10^{-13}$ sec, assuming a spin of $\frac{5}{2}$.

5877 LEVELS IN Gd^{156} FED BY THE DECAY OF 15-DAY Eu^{156}.

J.E.Cline and R.L.Heath.

Nuclear Phys. (Internat.), Vol. 22, No. 4, 598-609 (Feb., 1961).

Radiations following the decay of 15 day Eu^{156} were studied using the techniques of coincidence scintillation spectrometry and 4π-beta counting. Twenty-eight gamma-rays were identified as transitions from excited levels in Gd^{156}. The energies of these gamma-rays, along with their coincidence relationships, indicate that levels are present in the daughter nuclide at 89, 290, 520, 1150, 1240, 1250, 1320, 1360, 1960, 2030, 2180 and 2200 keV. Gamma—gamma directional correlation measurements were made leading to spin assignments for the levels at 1320, 1960 and 2030 keV.

5878 PROMETHIUM 148.
J.S.Eldridge and W.S.Lyon.
Nuclear Phys.(Internat.), Vol. 23, No. 1, 131-8 (Feb., 1961).

Promethium 148 was produced by two methods: (1) (n, γ) reaction on Pm^{147} (2) (p, n) reaction on enriched Nd^{148}. In both instances two activities were observed: 5.4 day Pm^{148} and 41.8 day Pm^{148}. The decay of these isomers was followed by use of ion-chambers, beta counters, and gamma scintillation spectrometers. Gamma-rays of 0.550, 0.910 and 1.460 MeV were found to be associated with the 5.4 day isomer with abundances of 0.25, 0.13 and 0.20 respectively. A negatron of 2.5 MeV is associated with the 5.4 day isomer with an abundance of approximately 55%. Gamma-rays of 0.085, 0.180, 0.210, 0.290, 0.410, 0.550, 0.630, 0.730, 0.910, 1.01 and 1.46 MeV were found to be associated with the 41.8 day isomer with relative abundances of 2, 6, 2, 14, 21, 100, 83, 38, 21, 21 and 2 respectively.

5879 THE HALF-LIFE OF THE FIRST EXCITED STATE OF Tl^{203}. E.C.B.Pederson and R.E.Bell.
Nuclear Phys. (Internat.), Vol. 21, No. 3, 393-6 (Dec. (1), 1960).

The half-life of the 279 keV excited state of Tl^{203} was measured from the logarithmic slope of a delayed coincidence curve. This method is preferable to the centroid shift method, which was used for previous delayed coincidence measurements, since it is much less sensitive to systematic effects and to drifts in the apparatus. The half-life was found to be $T_{1/2} = (2.41 \pm 0.10) \times 10^{-10}$ sec, in agreement with previous results from resonance fluorescence, but in moderate disagreement with most recent Coulomb excitation results.

NUCLEAR REACTIONS

(Including scattering by nuclei)

5880 AN UNIFIED THEORY OF DIRECT REACTIONS.
A.Agodi and E.Eberle.
Nuovo Cimento (Italy), Vol. 18, No. 4, 718-43 (Nov. 16, 1960).

A new dispersion theory of nuclear reactions is presented which is a generalization of the existing ones. The theory is centred around the possibility of defining a class of problems equivalent to the original scattering problem in the sense that their solutions all determine the same transition matrix elements. These equivalent problems are generated by suitably projecting the original one on a subspace of the linear space spanned by the continuum eigenstates of the total Hamiltonian, containing the initial and final channel states. A derivation of the Breit—Wigner formula analogous to Feshbach's can be given in this theory, independently of any configuration space representation. The direct processes are then defined by performing the energy average on the transition matrix elements, so that the contributions from the long-lived "compound" states are lost. In the case of nucleon—nucleus scattering this is shown to give an alternative definition of the optical model quite analogous to the conventional ones though perhaps more accessible to a field theoretical analysis. Moreover it is shown that the well known surface contributions to direct reactions can be isolated quite naturally in this formalism from the other direct contributions.

5881 DIRECT INTERACTIONS AND NUCLEAR MODELS.
M.Demeur.
Mem. Acad. Roy. Belgique Cl. Sci.(Coll. in 8^0), Vol. 32, No. 4, 36 pp. (1960). In French.

Formulates an approximation in which the Hamiltonian is made to change discontinuously, one or more times, during a direct interaction. Argues that this makes it easier to compare nuclear models. R.J.N.Phillips

5882 CORRECTIONS TO NUCLEAR Q VALUES RESULTING FROM ATOMIC BINDING AND EXCITATION.
R.F.Christy.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 301-5 (Jan., 1961).

Corrections to the measured energies of nuclear reactions associated with the binding and excitation of atomic electrons are calculated.

5883 ON PROCESSES IN THE INTERACTION OF γ-QUANT WITH UNSTABLE PARTICLES.
I.Ya.Pomeranchuk and I.M.Shmushkevich.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 452-67 (March, 1961).

Deals with various inelastic processes occuring in collisions fast particles with nuclei which are neither excited nor transforme At $q^2 = 0$ (q^2 being the invariant square of the momentum transfer a nucleus) the amplitude of these processes has a pole involving virtual photons. Therefore at sufficiently small q^2 the virtual pho exchange makes a larger contribution to the amplitude than the exchange of strongly interacting particles. This makes it possible t connect, at small q^2, the cross-section of the process considered here that of a process at work between a γ-quantum and an inciden particle. Given q^2 and E ≫ m (E being the energy of the incid particle in the laboratory coordinate system and m its mass), the energy w of the particles produced in the reaction in their centre of-mass system is restricted by the condition $w^2-m^2 < 2E_L \sqrt{q^2}$. The relation between the cross-sections, equivalent to one followi from the Weizsäcker—Williams method, is obtained in the present paper by a covariant method, and the conditions of applicability of this relation are discussed, in particular for strongly interacting particle processes. An appraisal is made of the contribution mad by the processes involving the Coulomb nuclear field to the total cross-section of interaction between the incident particle and the nucleus. The processes at work in the Coulomb field of the nucle such as the bremsstrahlung of π or K-mesons, the conversion of π-mesons into two π-mesons and the transformations of a Λ^0-part into Σ^0-particle are analysed in detail.

5884 AN INVESTIGATION OF NUCLEAR PROBES.
P.E.Hodgson.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 499-505 (March, 1961).

The optical model is used to study the sensitivity to the outer regions of the nuclear field of the elastic differential cross-secti for the scattering of neutrons, protons, deuterons, tritons, He^3 an alpha-particles by nuclei. It is found that the energy at which the sensitivity is greatest is given approximately by $ZZ'/A^{1/3}$ MeV, where Z and A refer to the target nucleus, and Z' to the probe particle.

5885 THE OPTICAL MODEL AND DEUTERON STRIPPING
J.E.Young.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 40-52 (Feb., 1961).

A development is given which stresses the underlying similar between the deuteron stripping theory on the one hand and direct interaction theory of inelastic nucleon scattering on the other. Th assumption here is that both formulations are given in distorted Born approximation. Some implications for the form of the stripp theory, e.g. construction of the distorting potentials are discussed The entire theory, as given, for the transition matrix element is first-order in the two-body scattering operators. Probable corre tions to this description, such as those arising from multiple scatt ing, are discussed.

Due to Photons

5886 THE ROLE OF REPULSIVE CORES IN THE PHOTONUCLEAR EFFECT. J.W.Clark.
Canad. J. Phys., Vol. 39, No. 3, 385-92 (March, 1961).

The dipole sum rule is used to investigate the effect of nucle forces on the integrated photonuclear cross-section σ_{int} of a larg nucleus, for a Serber potential containing a hard core. A Jastrow wave-function is assumed to describe the nuclear ground state, an the first term in the cluster expansion of the resultant expression for σ_{int} evaluated under two different sets of assumptions for the potential and correlation function, corresponding to two different studies of the nuclear matter problem. The presence of a repulsi core in the potential is found to enhance considerably the calculat σ_{int}, compared with the result for a potential without a core which fits the same (low-energy) two-nucleon data.

5887

INELASTIC SCATTERING OF HIGH ENERGY PHOTONS IN THE COULOMB FIELD OF A NUCLEUS WITH RODUCTION OF ELECTRON—POSITRON PAIRS (RADIATIVE AIR PRODUCTION).

B.De Tollis, G.J.Lasinio and R.S.Liotta.
uovo Cimento (Italy), Vol. 18, No. 3, 545-53 (Nov. 1, 1960).

Radiative pair production is studied and the differential cross-ection for two kinematical cases is given. The calculations are erformed with standard perturbation theory in Born approximation. 'or small angle θ and for incident γ energy available from modern ynchrotrons the two cross-sections are sufficiently high so that ney can be measured.

5888

DISPERSION RELATIONS FOR SOME PHOTON REACTIONS.

A.Minguzzi and R.F.Streater.
Iuovo Cimento (Italy), Vol. 18, No. 4, 806-12 (Nov. 16, 1960).

By using Dyson's integral representation directly for the bsorptive part of the T matrix, certain dispersion relations nvolving photons and nuclei are proved more simply than by the nethod of Bogoliubov et al. The range of validity is always less han that obtained by the best possible techniques, but fewer physical ssumptions are needed. In particular the existence of an inter-olating field associated with light nuclei is not needed. Photo-roduction, Compton scattergin and bremsstrahlung from nuclei an be treated in the usual e^2 approximation.

5889

ANGULAR DISTRIBUTIONS OF FAST PHOTONEUTRONS.

F.Tagliabue and J.Goldemberg.
Iuclear Phys. (Internat.), Vol. 23, No. 1, 144-52 (Feb., 1961).

The angular distribution of photoneutrons from thirteen elements vas measured with the $Si^{28}(n,p)Al^{28}$ threshold detector which is rimarily sensitive to neutrons with more than 6 MeV. The angular listributions observed do not, within the errors, show a definite naximum at 90° as expected by dipole absorption of the photons, xcept for Bi, Pb and Au. For Bi and Pb the experimental results re consistent with calculations made using Wilkinson's model.

5890

PHOTODISINTEGRATION OF Al^{27}. I. PHOTONEUTRON CROSS SECTION.

.E.E.Baglin, M.N.Thompson and B.M.Spicer.
Iuclear Phys. (Internat.), Vol. 22, No. 2, 207-15 (Jan., 1961).

The Al^{27} (γ,n) cross-section was observed up to 18.5 MeV with ood resolution. It contains a plateau at 14 MeV and a hump at 6 MeV, and is consistent with recent high-resolution measurements f the total absorption cross-section.

5891

PHOTODISINTEGRATION OF Al^{27}. II. THEORETICAL.

J.E.E.Baglin, M.N.Thompson and B.M.Spicer.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 216-25 (Jan., 1961).

The intrinsic level scheme calculated for a deformed nucleus by Nilsson was used in conjunction with a single-particle excitation model to compute the photonuclear electric dipole absorption cross-section for Al^{27}. The resultant curve contains peaks at 16, 18.5 and 21 MeV, in accord with the high-resolution experimental results of Mihailovic. The calculated energy distribution of photoneutrons contains high-energy direct emission groups, in agreement with experiment. Angular distributions computed also agree with experimental results. A new small cross-section peak is predicted near 26 MeV.

5892

CROSS-SECTIONS FOR THE (γ,n) REACTION IN Cu^{63}, Cu^{65}, Zn^{64}, Sb^{121} AND Pr^{141}, MEASURED WITH MONO-CHROMATIC GAMMA RAYS.

;.E.Coote, W.E.Turchinetz and I.F.Wright.
Iuclear Phys. (Internat.), Vol. 23, No. 3, 468-80 (March, 1961).

Cross-sections for the (γ,n) reaction in Cu^{63}, Cu^{65}, Zn^{64}, Sb^{121} nd Pr^{141} were measured using gamma-rays from the $Li^7(p,\gamma)Be^8$ nd $B^{11}(p,\gamma)C^{12}$ reactions. NaI:Tl crystals were used to monitor the adiation and to measure the residual activity. The $Cu^{63}(\gamma,n)Cu^{62}$ ross-section for the lithium radiation from the 440 keV resonance vas 59 ± 6 mb. The cross-sections at 12.2, 14.8, 16.7 and 17.6 MeV hen 11 ± 2, 33 ± 4, 63 ± 8 and 73 ± 8 mb, respectively. These esults confirm the bremsstrahlung measurement of the shape of he cross-section but the absolute cross-section values were 25% ower. Cross-sections for the lithium resonance radiation, measred relative to that of Cu^{63}, were: Cu^{65}, 70 ± 7 mb; Zn^{64}, 40 ± 4 mb; b^{121}, 122 ± 13 mb; Pr^{141}, 181 ± 20 mb. Comparison with previous esults suggests that discrepancies are due to inaccuracies in bsolute β-counting.

5893

THE FINE STRUCTURE OF THE ENERGY SPECTRUM OF PHOTOPROTONS AND THE LEVELS OF Li^6.

A.P.Komar and E.D.Makhnovskii.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 1, 52-4 (Nov. 1, 1960). In Russian.

The energy distribution of protons due to the (γ,p) and (γ,n) reactions arising from the illumination of Li^6 with bremsstrahlung γ-quanta having $E\gamma max = 28$ MeV was studied. Several discrete maxima were revealed, some outside the statistical error. In a detailed discussion of these peaks it is concluded that the reaction $Li^6(\gamma,p)Li^5 \rightarrow p + \alpha$ goes mainly through the ground state of Li^5 and that all the peaks for $Ep > 4$ MeV are due to resonance absorption of γ-quanta by Li^6 nuclei with a subsequent emission of protons and the formation of He^5 in the ground state. Some excited levels of Li^6 are listed. [English translation in: Soviet Physics—Doklady (USA)].

F.Herbut

5894

THE PHOTOPRODUCTION REACTION $^{60}Ni(\gamma,\pi^-)^{60}Cu$.

P.V.March and T.G.Walker.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 293-8 (Feb., 1961).

The cross-section for the reaction $Ni^{60}(\gamma,\pi^-)Cu^{60}$ was measured using bremsstrahlung having maximum energies from 120 MeV to 320 MeV. Radiochemical separation techniques were used to separate the Cu^{60} from the other activities produced by the irradiation. A comparison with previous results for the reaction $B^{11}(\gamma,\pi^-)C^{11}$ indicates that the reaction is due predominantly to surface production.

5895

PHOTOPROTONS FROM NITROGEN.

I.Wahlström and B.Forkman.
Ark Fys. (Sweden), Vol. 18, Paper 7, 83-95 (1960).

The results of a study of the (γ,p) reaction in N^{14} are presented. A target of nitrogen gas at 1 atm pressure was used. The source of photons was the bremsstrahlung beam of a 30 MeV synchrotron. Irradiations were carried out at 11.5 and 15.5 MeV maximum bremsstrahlung energy. The protons were recorded by means of nuclear emulsions. Both irradiations gave proton spectra containing well-resolved peaks. By comparing the two proton spectra the peaks could be identified as resonances in N^{14}. The result has been compared with the inverse process and measurements of (γ,n) and (γ,p); the agreement was found to be quite satisfactory. The cross-section of the (γ,p) reaction up to 15 MeV is given.

5896

ENERGY DEPENDENCE OF THE CROSS SECTION OF THE NUCLEAR REACTION $O^{16}(\gamma,n)O^{15}$.

L.Keszthelyi, I.Berkes, I.Demeter and I.Fodor.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 513-17 (March, 1961).

The resonances in the $O^{16}(\gamma,n)O^{15}$ reaction at 17.55 MeV and 17.68 MeV were investigated with the γ-radiation of $Li^7(p,\gamma)Be^8$ reaction. It was found that if these levels exist at all their widths exceed ~ 150 keV.

5897

THE PHOTODEUTERON YIELD FROM 30 MeV BREMSSTRAHLUNG IRRADIATION.

B.Forkman.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 269-84 (Feb., 1961).

An investigation of the (γ,d) reaction in sulphur, cobalt and copper was carried out. Bremsstrahlung of 30 MeV maximum energy was used. The emitted charged photoparticles were deflected by a magnetic field and recorded in nuclear emulsions. The range and the orientation of the tracks in the emulsions were measured and the trajectories of the photoparticles were calculated backwards for protons, deuterons and alpha-particles. The intersection point of each trajectory with the target plane gave information about the kind of photo-particle which had produced the track. The ratio R_{dp} between the (γ,d) yield and the (γ,p) yield was determined. No strong fluctuation in the ratio between the adjacent elements cobalt and copper, with a standard deviation of respectively 0.009, 0.012 and 0.018. A calculation based on the statistical model of the ratio R_{dp} was made. The ratios obtained are, within the limits of the errors, in agreement with the experimental results. The present results also were compared with the pick-up process theory, with earlier (γ,α) yield and the (γ,p) yield was in agreement with earlier (γ,α) experiments.

5898

THE REACTION $^{51}V(\gamma,\alpha)^{47}Sc$ AND SOME REMARKS ON (γ,α) REACTIONS.

J.H.Carver.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 417-23 (Feb., 1961).

The $V^{51}(\gamma,\alpha)Sc^{47}$ reaction was studied using induced radioactivity techniques up to gamma-ray energies of 32 MeV. The cross-section has a maximum value of 0.95 mb at an energy of 22 MeV and an integrated cross-section to 32 MeV of 12 ± 2 MeV mb. The statistical model gives a satisfactory interpretation of the ratio of the $V^{51}(\gamma,\alpha)$ cross-section to the $V^{51}(\gamma,n)$ cross-section measured by Goldemberg and Katz (Abstr. 3855 of 1954). It is probable that this interpretation can be applied to the (γ,α) yields from other middle-weight nuclei but it is not appropriate for the heavy nuclei ($Z > 50$). It is suggested that the roughly constant (γ,α) yields observed in the heavy nuclei may arise from direct electric dipole interactions with pre-formed "alpha-particles" in the nuclear surface.

Due to Electrons

5899 ON THE LONGITUDINAL DEPOLARIZATION OF BEAMS OF SPIN $\frac{1}{2}$ PARTICLES BY MULTIPLE COULOMB SCATTERING. G.Passatore.
Nuovo Cimento (Italy), Vol. 18, No. 3, 532-44 (Nov. 1, 1960).

The average longitudinal depolarization of an electron beam by multiple Coulomb scattering is evaluated. The treatment is based on the iteration, extended to a whole succession of scatterings, of the matrix which describes the variation of the polarization state for a single scattering, and on the average of the iterated matrix on all possible scattering successions. A very simple formula is obtained for the average longitudinal polarization degree of the whole outgoing beam, and the final expressions are evaluated by using the second Born approximation. Numerical values of the depolarization for Al and Au targets and for several values of energy and thickness are given; these values in all cases considered are never greater than a few percent.

5900 ASYMMETRY IN DOUBLE MOTT SCATTERING AND ABSOLUTE VALUES OF BETA-ELECTRON LONGITUDINAL POLARIZATION.
P.E.Spivak, L.A.Mikaelyan, I.Ye.Kutikov and V.F.Apalin.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 169-72 (Feb., 1961).

Asymmetry values of double unpolarized electron scattering on gold were measured. Absolute values of the longitudinal polarization of β-electrons of P^{32}, In^{114}, Au^{198}, Ho^{166}, Lu^{177} and Sm^{153} were obtained.

INELASTIC ELECTRON SCATTERING AND NUCLEAR COMPRESSIBILITY. See Abstr. 5824

Due to Nucleons

5901 SCATTERING OF PARTICLES ON HEAVY NUCLEI AND THE NUCLEON–NUCLEON CORRELATIONS.
J.Dabrowski.
Suppl. to Physica (Netherlands), Vol. 26, S155-S161 (Dec., 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). The possible effects of nucleon–nucleon correlations on nucleon–nucleus and electron–nucleus scattering are studied. Watson's scattering theory is used to calculate the optical-model potential for high energies, the interaction is taken to be separable, and the correlations are taken from calculations on nuclear matter. The effects are found to be small, of the order of 10%. Inelastic electron scattering should give a better method of studying correlations. The calculations are incomplete, but should lead to information about the accuracy of Brueckner theory and of the impulse approximation. D.J.Thouless

5902 THE SCATTERING OF HIGH ENERGY NUCLEONS BY COMPLEX NUCLEI. C.J.Batty.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 562-93 (March, 1961).

An analysis of nucleon–carbon scattering experiments in the energy range 90 to 1000 MeV has been made in terms of the optical model using the semi-classical approximation. Values of the differential cross-section and polarization at a number of angles and the absorption and total cross-sections were used in obtaining parameters given a "best-fit" to the experimental data. The analysis was made for protons of energies 95, 135, 220, 310, 420, 635 and 970 MeV and for 155 MeV neutrons. Calculations at various energies were also made using optical model potentials obtained by other workers from nucleon–nucleon scattering data.

5903 NUCLEUS–NUCLEUS REACTION CROSS SECTION AT HIGH ENERGY COLLISIONS.
G.Alexander and G.Yekutieli.
Nuovo Cimento (Italy), Vol. 19, No. 1, 103-17 (Jan. 1, 1961).

The nucleon–nucleus and nucleus–nucleus reaction cross-sections at high energies for various elements are calculated accor ing to the optical model as a function of σ_0, the effective nucleon–nucleon total cross-section in nuclear matter. Use is made of the charge distributions of various nuclei recently obtained from electron scattering experiments. The results are compared with existing data of experiments using machine beams and cosmic-ray particles. But for the very light nuclei, a general agreement is found fo values of σ_0 differing only by a few per cent from the free nucleon–nucleon total cross-section.

Due to Protons

5904 DETERMINATION OF THE PARITY CHANGE IN INELASTIC SCATTERING FROM THE ANGULAR DISTRIBUTION. A.J.Kromminga and I.E.McCarthy.
Phys. Rev. Letters (USA), Vol. 6, No. 2, 62-3 (Jan. 15, 1961).

The distorted-wave Born approximation is used to show that the inelastic cross-section is small for small momentum transfer, if there is a parity change in the nuclear state. E.J.Squires

5905 COULOMB EXCITATION OF Au^{197} AND W^{186} BY PROTONS OF ENERGY UP TO 12.6 MeV.
A.V.Cohen and J.A.Cookson.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 32-9 (Feb., 1961).

The excitation function for inelastic scattering of protons of energies between 6.7 and 12.6 MeV from Au^{197}, exciting the 279 keV level and the 548 keV level, was determined. Results are compare with the predictions of semi-classical theory, and reasons for possible discrepancies are discussed. The (2+) nature of the 730 keV level in W^{186} was confirmed.

5906 GAMMA RAYS CORRESPONDING TO A DIPOLE OR A HIGH QUADRUPOLE EXCITATION OF CARBON 12 BY 150 MeV PROTONS. N.Gilbert.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 362-76 (Feb., 1961).

The process $C^{12}(p, p'\gamma)C^{12}$ is formulated in direct interaction theory using the sum rule for a group of dipole states at about 20 MeV and for a group of quadrupole states that is assumed to be a about 30 MeV. The $p'-\gamma$ angular correlation is discussed and it is shown that for some $p'-\gamma$ and $p-p'$ angles the emission of an E2 γ-ray in this range has an appreciable probability.

5907 COULOMB EXCITATION OF Se^{77}.
W.R.Wisseman and R.M.Williamson.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 532-6 (March, 1961).

The 240 and 442 keV levels in Se^{77} were excited with 4.0 MeV protons and 3.5 MeV deuterons, and the scattered particles were observed at angles of 150° and 145°, respectively. They were studied with a magnetic analyser and detected by photographic plates. The B(E2) values which were obtained were 0.17 ± 0.02 and 0.26 ± 0.03 for the 240 and 442 keV levels, respectively. The ratio of these B(E2) values, 1.5 ± 0.2, is in good agreement with the ratio of 1.5 which is predicted by the unified model for rotational states and spin assignments $(\frac{1}{2}, \frac{3}{2}, \frac{5}{2})$ for the ground, 240 and 442 keV states.

5908 INELASTIC SCATTERING FROM Th^{232} AND U^{238}.
E.Z.Skurnik, B.Elbek and M.C.Olesen.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 316-17 (Jan., 1961).

The reduced electric-quadrupole transition probabilities and excitation energies of the first excited states in Th^{232} and U^{238} were determined from inelastic scattering measurements with protons and deuterons.

5909 STRUCTURE OF THE GIANT RESONANCE IN THE $Al^{27}(p, \gamma)$ REACTION.
M.Kimura, K.Shoda, N.Mutsuro, T.Tohei, K.Sato, K.Kuroda, K.Kuriyama and T.Akiba.
Nuclear Phys. (Internat.), Vol. 23, No. 2, 338-44 (Feb., 1961).

The variation of the cross-section for $Al^{27}(p, \gamma_0 + \gamma_1)Si^{28}$ with proton energy from 7.5 to 14.7 MeV, reveals the full structure of the giant resonance. Gamma-ray yields for transitions to the grou and first excited states of the product nucleus were measured using a large NaI: Tl crystal spectrometer. The width of the giant resonance is of the order of 4 MeV, with many resonance peaks and possibly with a splitting due to deformation.

5910 THE $B^{11}(p,\gamma\,\alpha)Be^8$ REACTION AND THE 9.63 MeV STATE OF C^{12}. A.G.Gregory.

Nuclear Phys. (Internat.), Vol. 23, No. 3, 518-23 (March, 1961).

An attempt to measure the cross-section for transitions between the 16.11 and 9.63 MeV states of C^{12} is reported and an upper limit of 30% of that for ground state transitions is given. Theoretical formulae are given for the observable coincidence rate in the $B^{11}(p,\gamma\alpha)Be^8$ reaction at 163 keV bombarding energy as a function of γ-detector acceptance angle for two positions of this detector. These formulae are used in conjunction with experimentally determined background rates to assess the possibility of determining the spin of the 9.63 MeV state of C^{12} by means of angular correlation measurements.

ANGULAR CORRELATION IN $Be^9(p,\gamma)B^{10}$. See Abstr. 5838

5911 THE POLARIZATION OF NEUTRONS FROM THE $Li^7(p,n)Be^7$ REACTION. I.

S.E.Darden, T.R.Donoghue and C.A.Kelsey.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 439-50 (Feb., 1961).

Previous measurements on the polarization of neutrons from the $Li^7(p,n)Be^7$ reaction were extended. Left—right asymmetries in the scattering of neutrons emitted from the reaction at a laboratory angle of 50° were measured using scatterers of Li^6, Li^7, O and Mg. Measurements were carried out for laboratory scattering angles near 90°, and for neutron energies between 85 and 420 keV. Data obtained using the Li^7, O and Mg scatterers were analysed to give the polarization of the neutrons emitted from the reaction. The measured polarizations are of the order of 0.4 down to 250 keV neutron energy, below which they decrease abruptly. Relatively small asymmetries observed using Li^6 as a scatterer suggest the antiparallel spin S-wave interaction may be the stronger for this nucleus.

5912 THE POLARIZATION OF NEUTRONS FROM THE $Li^7(p,n)Be^7$ REACTION. II.

S.M.Austin, S.E.Darden, A.Okazaki and Z.Wilhelmi.

Nuclear Phys. (Internat.), Vol. 22, No. 3, 451-67 (Feb., 1961).

The polarization of the $Li^7(p\ n)Be^7$ neutrons was deduced from measurements of the left—right asymmetry in the scattering of these neutrons from a liquid oxygen analyser. Angular distributions of the polarization (P_n) were measured at 2.2, 2.6 and 3.0 MeV covering angular ranges (laboratory system) of from 30° to 70°, 30° to 115° and 30° to 70°, respectively. For neutrons emitted at 50°, additional measurements were made at proton energies between 2.1 and 3.1 MeV. At 2.6 MeV the polarization P_n is close to zero at 105° and 115°, suggesting that at least two states formed by the same initial channel spin and having $l_1 + l_2 \geq 2$ contribute to the reaction. The polarization at 50° as a function of energy decreases rapidly from about 0.5 at 2.15 MeV to a broad minimum centered at 2.45 MeV, where the polarization is about 0.2 and then increases to a constant value near 0.3 at bombarding energies above 2.7 MeV. Polarizations and differential cross-sections calculated assuming that the reaction is described by the levels in Be^8 (which were postulated by Macklin and Gibbons to account for their measured total cross-sections) are not consistent with the experimental data. The results of calculations based on several other sets of level parameters are discussed. The unequal values of the reduced widths for emission of protons and neutrons observed for at least one level in Be^8 are explained in terms of the mixing by electromagnetic effects of states in Be^8 with the same spin and parity, but different isobaric spin.

5913 THE EXCITATION FUNCTION OF $Pr^{141}(p,n)Nd^{141}$ UP TO 11.1 MeV. J.Olkowsky, M. Le Pape and I.Gratot.

Nuclear Phys. (Internat.), Vol. 23, No. 1, 164-8 (Feb., 1961).
In French.

The absolute (p, n) cross-section of Pr^{141} was measured by the activation method at proton energies up to 11.1 MeV. The energy dependence agrees with that predicted by the optical model.

5914 CAPTURE AND INELASTIC SCATTERING OF PROTONS BY SILICON 30.

A.C.L.Barnard, S.Bashkin, C.Broude and C.E.Hornback.

Nuclear Phys. (Internat.), Vol. 23, No. 2, 327-37 (Feb., 1961).

The reactions $Si^{30}(p,\gamma)P^{31}$ and $Si^{30}(p,p'\gamma)Si^{30}$ were studied in the range of incident proton energies from 1.0 to 4.25 MeV. Some measurements were also made with Si^{28}. At $E_p = 3.88$ MeV the yield curves suggest that the weak resonance seen with natural silicon targets is caused by Si^{30} and not by Si^{28}. The capture reaction did not give useful information about spins and parities of P^{31} states, but the angular distributions of the gamma-rays following inelastic scattering led to assignments for 10 of these states.

5915 RESONANCE ENERGIES AND HALF-WIDTHS FOR PROTON CAPTURE IN SODIUM AND PHOSPHORUS.

S.L.Andersen, O.Dørum, E.Gautvik and T.Holtebekk.

Nuclear Phys. (Internat.), Vol. 22, No. 2, 245-8 (Jan., 1961).

The gamma-ray yield from proton-induced reactions in sodium and phosphorus was studied in the proton energy range between 0.7 and 1.5 MeV for sodium, and between 0.8 and 1.6 MeV for phosphorus. One new resonance in P^{31} at 1395 ± 0.7 keV was found. Relative determinations of the resonance energies were made with an accuracy of 0.05-0.1%. For 13 of the resonances in sodium and one of the resonances in phosphorus the half-widths were determined. For the rest of the resonances upper limits for the half-widths between 200 eV and 750 eV were determined.

5916 DEUTERON PRODUCTION IN PICK-UP REACTIONS. I.

E.G.Beltrametti, L.Ciuffolotti and G.Tomasini.

Nuovo Cimento (Italy), Vol. 18, No. 4, 676-87 (Nov. 16, 1960).

Some features of the deuteron production, by 120 MeV protons interacting in nuclear emulsions, are examined, which exhibit deviations from a simple independent particle model of the nucleus. The experimental results and the technique used to discriminate the deuterons are described.

5917 DEUTERON PRODUCTION IN PICK-UP REACTIONS. II.

E.G.Beltrametti and G.Tomasini.

Nuovo Cimento (Italy), Vol. 18, No. 4, 688-701 (Nov. 16, 1960).

An interpretation is given of the production of deuterons whose energy spectrum and angular distribution cannot be explained by a IPM (nuclear independent particle model) pick-up process. Use of the two-nucleon, or quasi-deuteron, nuclear model is made, and a reasonable agreement with the experimental data is obtained.

Due to Neutrons

5918 THE SCATTERING OF NUCLEONS BY NUCLEI AT VERY HIGH ENERGIES. L.R.B.Elton.

Nuclear Phys. (Internat.), Vol. 23, No. 4, 681-93 (March, 1961).

Experimental results on the scattering of neutrons by nuclei in the energy region 0.3-5.0 GeV are analysed in terms of a semi-classical approximation and this is compared with the classical treatment used in an earlier paper. The analysis is used to derive half-way radii of the nuclear density distributions and these are compared with the corresponding quantities obtained from electron scattering. An estimate is given of the magnitude of the depth of the real part of the optical potential in the 0.3-5.0 GeV energy region.

5919 DOPPLER EFFECT IN NEUTRON ABSORPTION RESONANCES. A.W.Solbrig, Jr.

Amer. J. Phys., Vol. 29, No. 4, 257-61 (April, 1961).

Although discussed almost 120 years ago, the Doppler effect is of importance today in theoretical physics and reactor technology. The theory of Doppler broadening of spectral lines by thermal atomic motion is well-known. This theory can be applied to nuclear neutron resonances because of similarity in shape of spectral and nuclear lines. Since such application is not completely satisfactory, different derivations have been worked out for the nuclear case. The more direct of these derivations is reviewed, and the technological importance of the nuclear Doppler effect is discussed.

5920 A MEASUREMENT OF THE NEUTRON ABSORPTION CROSS SECTION OF ALUMINIUM.

M.Brose and K.H.Beckurts.

Nukleonik (Germany), Vol. 2, No. 4, 139-41 (June, 1960). In German.

The 2200 m/s cross-section is given as 220 ± 13 mbarn.

C.G.Morgan

5921 CROSS-SECTION FOR THE $Be^9(n, \alpha)He^6$ REACTION.

R.Bass, T.W.Bonner and H.P.Haenni.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 122-30 (Feb.,1961).

The cross-section for the reaction $Be^9(n, \alpha)He^6$ was measured for neutron energies from 3.9 to 8.6 MeV by counting the induced He^6 activity. The cross-section falls smoothly from 93 mb at 4.0 MeV to 39 mb at 6.5 MeV and 32.5 mb at 8.5 MeV.

5922 NEUTRON TOTAL CROSS-SECTIONS IN THE ENERGY RANGE 15 TO 120 MeV.

P.H.Bowen, J.P.Scanlon, G.H.Stafford, J.J.Thresher and P.E.Hodgson.
Nuclear Phys. (Internat.), Vol. 22, No. 4, 640-62 (Feb., 1961).

A neutron time-of-flight spectrometer was used to measure the neutron total cross-sections of hydrogen, carbon, aluminium, copper, cadmium, lead and uranium at 64 energies in the range 15 to 120 MeV. The results are compared with previous work in this energy range and are analysed in terms of the optical model of the nucleus.

5923 THE PERSISTENCE OF NUCLEAR POLARIZATION PRODUCED BY THE CAPTURE OF POLARIZED THERMAL NEUTRONS.

A.H.Wapstra and D.W.Connor.
Nuclear Phys. (Internat.), Vol. 22, No. 2, 336-8 (Jan., 1961).

The relation between observed beta-asymmetry and the static magnetic guide field is investigated for the capture of neutrons by Li^7, F^{19} and Al^{27}

5924 ACTIVATION CROSS SECTIONS WITH 14 MeV NEUTRONS.

S.K.Mukherjee, A.K.Ganguly and N.K.Majumder.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 508-14 (Feb., 1961).

Some activation cross-sections were measured for the elements Na, Al, Sc, Cr, Cu, Ag and Bi using 14.8 MeV neutrons from the (DT) reaction. The cross-section values with their experimental errors are as follows:

$Na^{23}(n,p)Ne^{23}$ 29 mb ± 10%,
$Na^{23}(n,\alpha)F^{20}$ 222 mb ± 10%,
$Al^{27}(n,p)Mg^{27}$ 77 mb ± 10%,
$Sc^{45}(n,2n)Sc^{44m}$ 149 mb ± 15%,
$Sc^{45}(n,2n)Sc^{44}$ 179 mb ± 15%,
$Sc^{45}(n,\alpha)K^{42}$ 63 mb ± 15%,
$Cr^{50}(n,2n)Cr^{49}$ 32 mb ± 10%,
$Cr^{52}(n,p)V^{52}$ 105 mb ± 10%,
$Cu^{65}(n,p)Ni^{65}$ 29 mb ± 10%,
$Ag^{107}(n,2n)Ag^{106}$ (8.2 days) ~6500 mb,
$Ag^{107}(n,2n)Ag^{106}$ (24 min) 662 mb ± 10%,
$Ag^{109}(n,2n)Ag^{108}$ 833 mb ± 10%,
$Ag^{109}(n,p)Pd^{109}$ 2.7 mb ± 20%,
$Ag^{109}(n,\alpha)Rh^{106}$ 12 mb ± 25%,
$Bi^{209}(n,p)Pb^{209}$ 0.7 mb ± 15%,
$Bi^{209}(n,\alpha)Tl^{206}$ 0.6 mb ± 15%,

The cross-sections were measured in relation to 556 mb for the cross-section of $Cu^{63}(n,2n)Cu^{62}$ and 117 mb for the cross-section of $Al^{27}(n,\alpha)Na^{24}$ reactions. It was found that the (n,α) cross-section values follow more or less the empirical curve given by Blosser, Goodman and Handley (Abstr. 4323 of 1958).

5925 TOTAL NEUTRON CROSS-SECTION OF P AND S IN THE 3 TO 5 MeV ENERGY RANGE.

P.Cuzzocrea, S.Notarrigo, R.Ricamo and F.Vinci.
Nuovo Cimento (Italy), Vol. 18, No. 4, 671-7 (Nov. 16, 1960).

The total neutron cross-sections of P and S were measured for neutron energies between about 3 and 5 MeV. Transmission measurements were made in steps of 25 to 30 keV with a neutron energy spread of 30 to 60 keV. Neutrons were produced from the $D^2(d, n)He^3$ reaction with 2 MeV deuterons. Neutrons of various energies were obtained at various angles from the direction of the deuteron beam. The average total cross-section of the two neighbour nuclei at 4 and 5 MeV suggests the need for a refinement of the optical model.

5926 PRODUCTION OF Lu^{178} BY THE $Ta^{181}(n, \alpha)Lu^{178}$ REACTION IN THE NRX REACTOR.

P.Glentworth and R.H.Betts.
Canad. J. Phys., Vol. 39, No. 3, 381-4 (March, 1961).

A rare earth activity of half-life 19 ± 1 min, produced by irradiating tantalum in the fast neutron flux of the NRX reactor (Chalk River, Ontario) was shown to be a lutetium nuclide. The 19 ± 1 min activity was ascribed to Lu^{178} produced by the $Ta^{181}(n, \alpha)Lu^{178}$ reaction. Three γ-rays of 450 ± 15, 320 ± 15, and 680 ± 15 keV (very weak) are associated with the 19 ± 1 min Lu^{178} activity.

5927 CAPTURE OF SLOW NEUTRONS BY NUCLEI BOUND IN CRYSTALS.

H.E.Jackson, L.M.Bollinger and R.E.Coté.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 187-9 (Feb. 15, 1961).

The neutron analogue of the Mössbauer effect is investigated. Experimental determinations were made of the absorption of slow neutrons by uranium metal at room and at helium temperatures, and by U_3O_8 at room and at nitrogen temperatures. It is claimed that the results agree with theory assuming a Debye model for the solid in the case of uranium, but not in the case of U_3O_8.

J.W.Leech

5928 ANGULAR DISTRIBUTION OF THE $V^{51}(n, d)Ti^{50}$ GROUND STATE DEUTERONS.

I.Šlaus, P.Tomaš and N.Stipčić.
Nuclear Phys. (Internat.), Vol. 22, No. 4, 692-6 (Feb., 1961).

The angular distribution of deuterons from the reaction $V^{51}(n, d)Ti^{50}_{gs}$ was measured at the incident neutron energy of 14.4 MeV by means of a thin scintillator method. The data show a pronounced maximum at 40° indicating the predominance of the direc interaction process. A reasonable fit was obtained with a Butler $L_p = 3$ curve using $r_0 = 6.15 \times 10^{-13}$ cm. The reduced width was found to be 0.03.

Due to Mesons and Hyperons

5929 ANGULAR DISTRIBUTION AND POLARIZATION OF THE NEUTRONS EMITTED IN μ-CAPTURE IN CERTAIN LIGHT NUCLEI.

M.K.Akimova, L.B.Blokhintsev and E.I.Dolinsky.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 369-85 (March, 1961).

Calculations of the energy spectra, angular distributions and polarization of direct-process neutrons formed in μ-capture in the nuclei of C^{12}, Ne^{20}, Si^{28} and S^{32} are performed on the basis of the effective Hamiltonian for μ-capture taking account of relativistic effects of first order with respect to v/c for nucleons, including "weak magnetism" and effective pseudoscalar interaction. The proton states in the nucleus are described by the nuclear shell model with jj-coupling; the interaction of the emitted neutrons and the nuclei is taken into account via an optical model. The results obtained are compared with experimental data.

5930 "HAMMER" TRACKS EMITTED FROM NUCLEAR DISINTEGRATIONS PRODUCED BY 4.6 GeV/c π^--MESONS.

G.C.Deka, D.Evans, D.J.Prowse and M.Baldo-Coelin.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 657-66 (March, 1961).

Results are given concerning the energy and angular distribution of Li^8 fragments produced from interactions of 4.6 GeV/c π^--mesons with the heavy nuclei in emulsions. It is shown that the frequency of Li^9 and Be^8 is low and that the Li^8 production cannot be completely described in terms of evaporation theory. The energy distribution of the α-particles from Li^8 decay is given and its interpretation discussed.

Due to Deuterons

5931 SCATTERING OF HIGH-ENERGY POLARIZED DEUTERONS BY CARBON.

B.A.Robson.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 672-80 (March, 1961).

It is shown that the inclusion of a small tensor force in the effective deuteron—carbon potential gives a more satisfactory description of the tensor components of polarization.

5932 NEUTRON—GAMMA ANGULAR CORRELATION STUDIES OF THE $B^{11}(d,n\gamma)C^{12}$ REACTION.

J.B.Garg, N.H.Gale and J.M.Calvert.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 630-47 (March, 1961).

Several (n—γ) angular correlations of the neutron group leading to the 4.43 MeV level in C^{12} and the associated γ-rays from the reaction $B^{11}(d,n)C^{12}$ were measured using time-of-flight techniques. The energies of the incident deuterons were 2.65 MeV and 5.35 MeV and the angles of the outgoing neutron direction were chosen at intervals of about 20°. The results of these measurements clearly show that the simple theory of Butler stripping is quite inadequate to describe the detailed features of the reaction mechanism but that good qualitative agreement of the results might be obtained with the distorted wave theory. Moreover the (n—γ) angular correlation measurements for backward angles of the neutrons do not show the expected features of the heavy-particle stripping mechanism, which has been used by other authors to account for the intensity of neutrons emitted at backward angles.

5933 A STUDY OF THE $Be^9(d,n)B^{10}$ REACTION BY MEANS OF NUCLEAR EMULSIONS. E.Hjalmar and H.Slätis.
Ark. Fys. (Sweden), Vol. 18, Paper 11, 193-208 (1960).

The energy distribution of neutrons from the $Be^9(d,n)B^{10}$ reaction for 7 MeV deuterons was studied by means of nuclear emulsions. Only 90° scattered neutrons were investigated. The existence of an excited level of about 3.1 MeV roughly confirms the 2.88 MeV level found by Reid and the 2.95 MeV level observed by Génin. Because of the high neutron background from the gold backing for neutron energies below about 4 MeV, the mean measurements were concentrated on neutron energies $>\sim$ 4 MeV. The energy distribution of neutrons from the Au(d, n)Hg reaction, thick gold target, is given. An equipment for measuring the deuteron-energy distribution of the internal cyclotron-beam by means of nuclear emulsions was constructed and used. The new microscope mechanical object stage described earlier (Abstr. 3367 of 1959) proved to be very useful, making possible more accurate and much faster measurements than before.

5934 SOME $Be^9(d,p\gamma)Be^{10}$ ANGULAR CORRELATION MEASUREMENTS OFF THE STRIPPING PEAK.
F.H.Read, J.M.Calvert and G.Schork.
Nuclear Phys. (Internat.), Vol. 23, No. 3, 386-98 (March, 1961).

Angular correlations, in the reaction and azimuthal planes, between protons and gamma rays from the first excited state of Be^{10} in the reaction $Be^9(d,p\gamma)Be^{10}$, were measured for four proton angles between 26° and 86° in the centre-of-mass system. For a pure stripping reaction, with $l = 1$ for the stripped neutron, only $P_2(\cos\theta_{p\gamma})$ terms are allowed in the angular correlation function in the reaction plane. However, P_4 terms were even on the stripping peak, indicating a compound-nucleus contribution to the reaction. Excitation functions for the reaction products of $Be^9 + d$ were measured for incident energies from 3.8 to 6.3 MeV and these show an absence of resonances. Absolute differential cross-sections for the ground state and first excited state proton groups from the $Be^9(d,p)Be^{10}$ reaction were measured at an incident energy of 5.86 MeV; these were analysed in terms of the Butler stripping theory to give cut-off radii and reduced neutron widths.

5935 POLARIZATION OF PROTONS FROM LOW RESONANCES IN $^{12}C(d,p)^{13}C$.
A.G.Gregory and P.B.Treacy.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 499-507 (Feb., 1961).

The polarization of protons from the $C^{12}(d,p)C^{13}$ reaction was measured at deuteron energies from 790 to 1100 kV at angles of 45°, 60°, 90°, 120° and 135°, using a carbon polarimeter. Published angular distributions were analysed in conjunction with the present results in terms of compound-nucleus theory. Previous assignments of 1^+ and 2^- for the first two resonance levels are confirmed. Analysis of the present results seems to imply a ratio of reduced width amplitudes for d- to s-wave deuterons larger than that suggested by previous measurements of the angular distribution. However, in fitting these results, it was found necessary to assume phase angles other than those required in the usual theory of resonance reactions.

5936 THE $C^{12}(d,n)N^{13}$ REACTION UP TO 1.35 MeV.
A.N.James.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 648-56 (March, 1961).

Angular distributions and excitation functions were measured for the ground-state neutron group in $C^{12}(d,n)N^{13}$ in the energy range E_d = 0.7 MeV to 1.35 MeV. The results are interpreted in terms of compound nucleus formation. A comparison with $C^{12}(d,p)C^{13}$ is made.

5937 EXCITATION FUNCTIONS OF (d,α) AND $(d,\alpha n)$ REACTIONS ON NATURAL TUNGSTEN. A.Demildt.
Nature (GB), Vol. 189, 51 (Jan. 7, 1961).

Stacked tungsten foils were irradiated in the internal deuteron beam of the Amsterdam synchrocyclotron. The maximum deuteron energy used was 22 MeV and the energy of deuterons in successive foils was calculated from the range—energy curve for tungsten. Activities due to tantalum isotopes produced by the reactions $W^{184}(d,\alpha)Ta^{182}$, $W^{186}(d,\alpha)Ta^{184}$ and $W^{186}(d,\alpha n)Ta^{183}$ were separated by selective liquid—liquid extraction with di-isobutylketone in hydrofluoric—hydrochloric acid medium in the presence of a tantalum carrier. The activities were counted absolutely by means of an end-window Geiger tube. Results are quoted for the cross-section of these reactions as a function of deuteron energy from 9 to 21 MeV.

R.E.Meads

Due to Alpha-particles

5938 MULTIPLE-SCATTERING OF 8 MeV α-PARTICLES IN LEAD. H.Fleischmann.
Z. Naturforsch. (Germany), Vol. 15a, No. 12, 1096-1100 (Dec., 1960). In German.

A check of Molière's theory was made using α-particles from ThC and ThC' incident on a lead foil of 10.93 mg/cm² thickness. The results for the B-parameter and the screening angle χ_a agree with theory within the experimental errors (2.5% and 7% respectively). With a mean impact number $\Omega = 29$, corresponding to 2.6 mg/cm² of lead, the B-parameter is enhanced by 7 ± 3%, an increase expected within the limits of the theory.

S.J.St-Lorant

COULOMB EXCITATION WITH 14-40 MeV α-PARTICLES IN THE RARE EARTH REGION. See Abstr. 4833

INVESTIGATION OF γ-RAYS FROM Mg^{24}, Mg^{25}, Mg^{26} ISOTOPES BOMBARDED WITH Po α-PARTICLES. See Abstr. 5842

5939 THE POPULATION RATIO OF THE 4.433 MeV AND 7.656 MeV STATES IN ^{12}C IN THE REACTION $^9Be(\alpha,n)^{12}C$, AND THE PARAMETERS OF THE 7.656 MeV LEVEL.
N.H.Gale and J.B.Garg.
Nuovo Cimento (Italy), Vol. 19, No. 4, 742-51 (Feb. 16, 1961).

A pulsed beam neutron time-of-flight spectrometer was used to study the reaction $Be^9(\alpha,n)C^{12*}$ at bombarding energies of 5.53, 5.76 and 5.97 MeV. Angular distributions of neutron groups leading to the ground state and first two excited states of C^{12} were measured, and the population ratio of the 4.433 and 7.656 MeV levels established as 10.7 ± 0.8 at ~ 5.5 MeV. In conjunction with other evidence the measured value of population ratio establishes the alpha-particle decay width of the 7.656 MeV level as approximately the Wigner limit, the spin and parity as 0+, and allows estimates to be made of the probabilities of pair and γ decay of this state.

5940 A STUDY OF THE REACTIONS $^{12}C(^3He,n)^{14}O$ AND $^{16}O(^3He,n)^{18}Ne$. J.H.Towle and B.E.F.Macefield.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 399-416 (Feb., 1961).

The time-of-flight and slow-neutron threshold techniques in conjunction with He^3 particles of energies of up to 11 MeV, were used to measure the Q-value of the $O^{16}(He^3,n)$ reaction and to locate levels in O^{14} and Ne^{18}. The Q-value, −3.199 ± 0.006 MeV, requires a mass defect of 10.649 ± 0.008 MeV for Ne^{18}. Levels were found in O^{14} at 5.905 ± 0.012, 6.30 ± 0.03, and 6.586 ± 0.012 MeV; and in Ne^{18} at 1.880 ± 0.010, 3.362 ± 0.011 and 3.608 ± 0.012 MeV. Excitation functions were measured between 2.0 and 5.7 MeV for both reactions. Angular distributions of the $C^{12}(He^3,n)$ reaction measured at 4.65, 4.98 and 5.26 MeV, were compared with theory of a double stripping process. The data suggest that a direct process is competing strongly with compound nucleus formation in this energy region.

5941 NEUTRON ANGULAR DISTRIBUTIONS FOR THE REACTION $^{16}O(^3He,n)^{18}Ne$.
N.H.Gale, J.B.Garg and K.Ramavataram.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 500-4 (Feb., 1961).

The angular distributions of neutrons leading to the ground state of Ne^{18} in the reaction $O^{16}(He^3,n)Ne^{18}$ were measured at bombarding energies of 5.6 and 6.09 MeV, using a pulsed-beam time-of-flight neutron spectrometer. The angular distributions were found to be strongly peaked in the forward direction. The results were compared with a double-stripping theory, and good agreement was obtained with the theoretical prediction for $l = 0$ stripping. It is, however, impossible from the angular distributions alone to exclude the possibility that the reaction proceeds by a knock-out mechanism. If the mechanism is that of double-stripping, the results lead to the assignment of spin zero and even parity to the ground state of Ne^{18}, in accordance with expectation.

Due to other Particles and Nuclei

5942 SODIUM-24 EXCITATION FUNCTION FOR LITHIUM-6 IONS ON ALUMINIUM. I.M.Ladenbauer.
Nuclear Phys. (Internat.), Vol. 23, No. 4, 559-61 (March, 1961).

The excitation function for the reaction $Al^{27}(Li^6; 5p,4n)Na^{24}$ was measured using the stacked-foil technique. The large constant cross-section of 43 mb over the energy region from 37 to 63 MeV total beam energy makes this reaction suitable for beam flux monitoring in other nuclear chemical studies.

5943 UPPER LIMITS FOR THE RADIATIVE CAPTURE CROSS SECTIONS OF ^{27}Al AND ^{31}P FOR ^{16}O IONS.
R.F.Coleman, D.N.Herbert and J.L.Perkin.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 526-30 (Feb., 1961).

The radiative capture cross-sections of Al^{27} and P^{31} for O^{16} ions with energies a few MeV above the expected thresholds for these reactions (~ 30 MeV) were found to be not greater than 0.2 and 18 μb respectively. Activation methods were used and care was taken to avoid errors due to impurities in the targets and the recoil into the targets of reaction products from elsewhere in the irradiation assembly. A calculation based on the statistical theory of the compound nucleus predicts a cross-section of 2 μb for the capture in aluminium of O^{16} ions at the energy used in these experiments. Various possible reasons for this over-estimation of the cross-section are discussed.

Nuclear Fission

NUCLEAR OCTUPOLE DEFORMATION AND THE MECHANISM OF FISSION. See Abstr. 5825

5944 THE TRIPLE SPONTANEOUS FISSION OF Cm^{242}.
N.A.Perfilov, Z.I.Solov'eva, R.A.Filov and G.I.Khlebnikov.
Dokl. Akad. Nauk SSSR, Vol. 136, No. 3, 581-2 (Jan. 21, 1961). In Russian.

The frequency of emission of an energetic α-particle as a third fission fragment was found, by a photographic plate method, to be about once in every 300 fissions. The energy distribution of the α-particles is similar to that found in the triple fission of U^{235} by thermal neutrons. [English translation in: Soviet Physics—Doklady (USA)] J.E.Gore

5945 THE COMPLEX FISSION OF URANIUM BY 14 MeV NEUTRONS. N.A.Perfilov and Z.Z.Solov'eva.
Atomnaya Energiya (USSR), Vol. 5, No. 2, 175 (1958). In Russian.

A study of the emission of long-range α-particles accompanying the fission of uranium by 14 MeV neutrons showed that such events do not differ markedly from the fission events due to the thermal neutrons. [English translation in: Reactor Science (GB), Vol. 10, No. 1-2, 89-90 (July, 1959)]. C.J.Batty

5946 MASS AND CHARGE DISTRIBUTION IN HIGH-ENERGY INDUCED FISSION. G.Rudstam and A.C.Pappas.
Nuclear Phys. (Internat.), Vol. 22, No. 3, 468-83 (Feb., 1961).

Low-energy fission data were used to estimate the symmetric fission probability and its energy dependence. Using this function together with characteristics of symmetric and asymmetric fission modes, the mass and charge distributions in high-energy induced fission were obtained. A numerical calculation of the mass distribution to be expected in the fission of uranium with 180 MeV protons gives reasonable agreement with experimental results, and the extrapolations from low-energy data seem justified. The mass dependences of the apparent neutron-to-proton ratio of the most probable primary fission fragment and of the width of the charge distribution therefore are estimated. A comparison with experimental data shows that neither the hypothesis of unchanged charge distribution nor that of equal charge displacement alone can explain the observed trends, but suggests a mass dependent mixture of both.

5947 MEASUREMENTS OF NEUTRON SPECTRA FROM FISSION. T.W.Bonner.
Nuclear Phys. (Internat.), Vol. 23, No. 1, 116-21 (Feb., 1961).

The neutron spectra from the fission of U^{235}, U^{233}, and Pu^{239} by thermal neutrons were measured by means of the sphere moderated neutron spectrometer. The spectra fit a Maxwellian distribution of the form $N(E) = \sqrt{E}e^{-E/\theta}$. The value of the energy parameter θ was found to be 1.332 ± 0.030 MeV in the case of U^{235} + n; the energies of the prompt neutrons from the fission of U^{233} and Pu^{239} were respectively 1.8% and 4.0% greater than that of U^{235}. Experiments on the spontaneous fission of Pu^{240} and Cf^{252} give value of θ of 1.189 and 1.367 MeV. The most probable energy of the leakage neutrons from Jezebel was found to be 15% lower than that of Pu^{239} + n. The variation of the energy of fission neutrons with $\bar{\nu}$ is compared to evaporation theory.

5948 RANGE AND KINETIC ENERGY DISTRIBUTIONS OF U^{233} FISSION FRAGMENTS.
K.A.Petrzhak, Yu.G.Petrov and É.A.Shlyamin.
Zh. eksper. teor. Fiz. (USSR), Vol. 38, No. 6, 1723-8 (June, 1960).

The range distribution of U^{233} fission fragments (Sr^{91-92}, Y^{92-93} Zr^{97}, Ba^{140}, Ce^{143}) was found in various gases. The dependence of the range distribution on the nature of the gas was established. From the range distribution the kinetic energy distribution due only to fission processes was determined. The results are compared w the published experimental data and Fong's statistical theory. (Abs 4629 of 1956). [English translation in: Soviet Physics — JETP (USA), Vol. 11, No. 6, 1244-7 (Dec., 1960)].

Thermonuclear Reactions

5949 RESEARCH ON CONTROLLED THERMONUCLEAR REACTIONS IN THE USSR. L.A.[S.] Artsimovich.
Uspekhi fiz. Nauk (USSR), Vol. 66, No. 4, 545-69 (Dec., 1958). In Russian.

The 1958 Geneva Conference review of Russian work and assessment of CTR prospects. See also Abstr. 3678 of 1959. [English translation in: Soviet Physics—Uspekhi (USA), Vol. 1, No. 2, 191-207 (Nov.-Dec., 1958)]. R.S.Pea

NEUTRON-PRODUCING MECHANISM IN TRANSVERSE PINCHE See Abstr. 2976

PLASMA PHYSICS AND THE PROBLEM OF CONTROLLED THERMONUCLEAR REACTIONS. See Abstr. 5439

NUCLEAR POWER STUDIES

5950 POWER REACTORS AND REACTOR SAFETY. T.J.Thompson.
Energia nucleare (Italy), Vol. 8, No. 1, 62-70 (Jan., 1961).

The problem of setting up a relationship between public safety and radioactivity release from reactors in normal operation as we as in the case of accident is discussed, followed by a delineation o the safety criteria which would determine the reactor design (container, pressure vessel, fuel elements, instrumentation and contro construction (inspection and testing) and operation (selection, trai ing and organization of the personnel). These considerations are confined to water moderated reactors.

5951 RANDOM FLUCTUATIONS IN A NUCLEAR FISSION REACTOR. L.G.Kemeny and Samaun.
Nature (GB), Vol. 189, 130-1 (Jan. 14, 1961).

Experiments concerning the measurement of time-dependent reactor parameters are briefly described. Use of a spectral analysis technique provided sufficient information to enable a plot the reactor transfer function or the power spectral density of the reactor "noise" to be made. The effective prompt neutron lifetim in the reactor core was found to be 174 μsec with an experimenta accuracy of 7% which is consistent with the accuracy of delayed ne tron data at present available. B.Bro

5952 NIOBIUM — PROMISING HIGH-TEMPERATURE REACTOR-CORE MATERIAL.
J.A.DeMastry and R.F.Dickerson.
Nucleonics (USA), Vol. 18, No. 9, 87-90, 132, 134 (Sept., 1960).

A summary of the physical properties of pure niobium and its alloys. Its high strength, high melting point and low neutron capt make it suitable for use in nuclear reactors. R.D.Sm

5953 PROPERTIES OF URANIUM MONOCARBIDE. C.A.Smith and F.Rough.
Nuclear Sci. Engng (USA), Vol. 6, No. 5, 391-5 (Nov., 1959).

Specimens of uranium monocarbide of nearly theoretical dens were prepared by arc melting and casting. Physical property measurements of the unirradiated materials included hardness, density, electrical resistivity, thermal conductivity, linear expans modulus of elasticity, and compatibility with NaK and stainless ste One group of specimens has been irradiated in the MTR to a burn of 1400 MWd/ton of uranium. Swelling was found to be in the rang of 0.66 to 2.53%. Fission recoil from the surface of the specimen could account for the observed gas release.

5954
SPECTRUM OF THERMAL NEUTRONS FROM THE EXPERIMENTAL REACTOR OF THE INSTITUTE OF ATOMIC PHYSICS OF THE ROUMANIAN [R.P.R.] ACADEMY.

H.Teutsch, S.Apostolescu and P.Timiş.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 465-72 (1959).
In Roumanian.

The spectrum of thermal neutrons in a horizontal channel of the VVR-S reactor at the Institute of Atomic Physics was determined using a thermal neutron spectrometer based on the time-of-flight method. The distribution obtained is given, to good approximation, by a Maxwellian function of the form $F(t) = \text{const.}\ t^{-4} \exp[-(t_0/t)^2]$, where t is the time of flight of the neutrons and $t_0 = 1481\ \mu s$, which corresponds to a neutron temperature of $390 \pm 17^\circ K$. During the determination, the temperature of the moderator inside the reactor was $297^\circ K$. In addition, an absolute method for determining the origin of the time scale is described. D.W.L.Sprung

5955
AUTOMATIC APPARATUS FOR MEASURING LOCAL GRADIENTS OF NEUTRON FLUX IN A REACTOR.

P.Mulot, R.Poussot, A.P.Schmitt and C.P.Zaleski.
Nuclear Instrum. and Methods (Internat.), Vol. 8, No. 2, 185-94 (Aug., 1960). In French.

An apparatus designed to measure strong gradients of neutron flux is described. Strips of material to be activated are exposed to the neutron flux and the induced beta activity is measured as function of position. The electronic and mechanical parts of the apparatus are described, and performance data are presented.

THERMAL DIFFUSION LENGTH MEASUREMENTS ON GRAPHITE IMPREGNATED BY DIPHENYL. See Abstr. 5732

5956
INSTRUMENTATION FOR EXPERIMENTAL REACTOR KINETIC STUDIES.

E.L.Gardner.
Trans Amer. Inst. Elect. Engrs I, Vol. 79, 384-8 (1960) = Commun. and Electronics, No. 50 (Sept., 1960).

Describes kinetic experiments in an experimental reactor of the homogeneous solution type. By the use of a pneumatic accelerator, step functions of reactivity were produced. Periods of 2 msec or less were recorded. Special instrumentation was devised to measure the amount of reactivity release, the initial fuel temperature, the core pressure and the initial power level. A.E.I.Research Laboratory

ATOMIC AND MOLECULAR PHYSICS

5957
PROBLEMS IN PERTURBATION THEORY CALCULATION OF DIAMAGNETIC SUSCEPTIBILITY AND NUCLEAR MAGNETIC SHIELDING IN MOLECULES. ILLUSTRATION WITH THE HYDROGEN ATOM.

L.C.Snyder and R.G.Parr.
J. chem. Phys. (USA), Vol. 34, No. 3, 837-42 (March, 1961).

The perturbation theory expressions for the diamagnetic susceptibility and nuclear magnetic shielding constants of atoms and molecules may be written as sums of ground state and excited state terms. The effects of truncations in the evaluation of the excited state terms are studied through a specially contrived application of these expressions to the hydrogen atom. When the origin of the vector potential is taken $1.4a_0$ away from the proton, computations of both properties show that the excited state part is comparable with the ground state part, that the continuum excited states contribute about as much as the discrete excited states, and that the first excited discrete state accounts for about a third of the whole excited-state contribution. The inference is made, for molecules, that truncation of conventional perturbation formulae by omission of continuum contributions will result in major errors and a dependence of computed properties on the origin taken for the vector potential. The average excited state energy required to make a correct sum-rule estimate of the excited state part of the nuclear magnetic shielding constant of the hydrogen atom is calculated, and it is shown to depend strongly on the distance of the shielded position from the proton.

5958
EFFECT OF RADIOFREQUENCY RESONANCE ON THE NATURAL LINE FORM.

M.N.Hack and M.Hamermesh.
Nuovo Cimento (Italy), Vol. 19, No. 3, 546-57 (Feb. 1, 1961).

The form of Zeeman lines in the presence of a resonant rotating r.f. magnetic field is determined. The spontaneous emission distributions are obtained from the steady-state solutions, leading to a prediction of the splitting of Zeeman lines at rotation frequencies corresponding to well separated single- and multiple-quantum resonance frequencies, as well as at the resonance frequency in the Majorana case.

5959
QUANTUM CHEMISTRY SUMMER INSTITUTE.

A.Gold.
Phys. Today (USA), Vol. 14, No. 1, 40-2 (Jan., 1961).

An account of the third course of a series, arranged jointly by the Quantum Chemistry Group of the University of Uppsala and the Quantum Theory Group of the University of Florida. It was held at Uppsala, Sweden from 17 July to 21 August 1960. There were one hundred participants from twenty centres.

ATOMS

5960
GREEN'S FUNCTION METHOD FOR QUANTUM CORRECTIONS TO THE THOMAS—FERMI MODEL OF THE ATOM.

G.A.Baraff and S.Borowitz.
Phys. Rev. (USA), Vol. 121, No. 6, 1704-13 (March 15, 1961).

A systematic method is presented for deriving the Thomas—Fermi equation for an atom and the quantum corrections from the many-body description. The novel feature of the method is that it does not require any a priori assumptions about the assignment of electrons to fully occupied single-particle states or about the distribution of electrons in phase space, but shows instead that the distribution which is usually assumed, or derived from the assumption of fully occupied single particle states, is a direct consequence of specifying that the many-particle system is in its ground state. The procedure used in the derivation is the expansion of the mixed position-momentum representation of the Green's function in a series of powers of $\hbar$. The lowest-order term is found to correspond with the Thomas—Fermi density. The form of the higher-order terms, which are to be considered as corrections to zeroth-order term, depends on the approximations made in the many-body equations for obtaining the Green's function. This paper deals only with the Hartree—Fock approximation, but the methods presented here allow generalization to other approximations which can include correlation effects.

5961
AN APPROXIMATE METHOD FOR THE CALCULATION OF MULTIPOLE POLARIZABILITIES OF ATOMS.

A.L.Stewart.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 477-50 (Feb., 1961).

The method devised by Vinti (Abstr. 5258 of 1932) is modified to calculate values of the multipole polarizabilities and nuclear quadrupole shielding factors of the two-electron systems. The results are used to compute the long-range interaction energy curve for a proton and a helium atom.

5962
GROUND-STATE PHASE SHIFT IN THE STATISTICAL THEORY OF THE ATOM.

T.Tietz.
Ann. Phys. (Germany), Vol. 6, No. 5-6, 233-5 (1960). In German.

An expression for the coherent electron scattering phase shift for $l = 0$ is derived. The Thomas—Fermi potential is closely approximated by an expression which allows an analytic solution of the wave equation. The phase shift is given by an analytic expression involving a ratio of products of gamma-functions. P.M.Parker

5963 THE BOUND FREE CONTINUUM FOR C^-.
R.G.Breene Jr.

Planet. Space Sci. (GB), Vol. 2, No. 1, 10-16 (Oct., 1959).

The wave-functions for the ground state of carbon and the negative carbon ion are determined using a small-variation programme. The Coulomb potential for the free electron is then computed using the carbon wave-function thus obtained, and the subsequent obtaining of the s- and d-wave portions of the free electron wave-function is detailed. The dipole length form of the matrix elements is then determined for the various desired values of the free electron momenta under the assumption that the lower state is the complete negative carbon ion wave-function while the upper states is the antisymmetric product made up of the free electron plus the complete neutral carbon atom wave-functions. Finally a simple calculation using the matrix element results provides the photo-ionization cross-section.

5964 $(^3P)nf$ LEVELS OF Cl I.
L.Minnhagen.

J. Opt. Soc. Amer., Vol. 51, No. 3, 298-302 (March, 1961).

By means of theoretical energy expressions for the p^4f configuration in pair-coupling 16 levels found in Cl I by Corliss and by Humphreys and Paul were identified as $(^3P)4f$, 5f, and 6f levels. Additional pairs of levels that make the $(^3P)4f$ and 5f configurations complete were found. The positions of the remaining $(^3P)6f$ pairs are accurately predicted. The coupling is found to be a pronounced pair coupling, and the levels are very hydrogenlike. From the $(^3P)nf$ series a new value for the $3p^4\ ^3P_2$ ionization limit (104 591 cm^{-1} above the ground level $3p^5\ ^2P1\frac{1}{2}$) was derived.

5965 WAVE FUNCTIONS AND CORRELATION ENERGIES FOR F, F^-, AND Ne.
L.C.Allen.

J. chem. Phys. (USA), Vol. 34, No. 4, 1156-60 (April, 1961).

Hartree—Fock solutions are obtained by the finite expansion technique and a comparison is made with other computational methods and results. Total energies, correlation energies, and one-electron parameters are presented as well as a tabulation of the radial functions in analytic form. The correct sign and order of magnitude of the fluorine electron affinity is predicted.

5966 THE HARTREE ENERGIES OF THE HELIUM SEQUENCE.
M.Cohen and A.Dalgarno.

Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 165 (Jan., 1961).

An exact solution of the equation derived in Abstr. 9739 of 1960 confirms the variational estimate of the leading term; it also suggests that terms in ln r and in 1/r should be included in trial wave-functions used in determining Hartree—Fock orbitals.

J.Hawgood

5967 CALCULATION OF THE LOWER EXCITED ENERGY LEVELS OF HELIUM.
H.F.Hameka.

J. chem. Phys. (USA), Vol. 34, No. 3, 884-6 (March, 1961).

The energies of the 1^1S, 2^1S, 2^3S, 2^1P, and 2^3P states of helium are calculated according to a method due to Pluvinage. It was shown that the Coulomb electronic repulsion term may be replaced by an effective potential function that accounts for first-order electronic repulsion effects on the wave-functions. The deviations between calculated and experimental energy values vary between 0.01 and 0.06 a.u.

5968 DEPARTURES FROM THE SAHA EQUATION FOR IONIZED HELIUM. I. CONDITION OF DETAILED BALANCE IN THE RESONANCE LINES.
R.N.Thomas and J.B.Zirker.

Astrophys. J. (USA), Vol. 133, No. 2, 588-95 (March, 1961).

Conditions for the validity of the assumption of detailed balance in the Lyman lines of He II are investigated. An opacity of 10^6 in Lyman-α is required, which implies high opacity in the subordinate lines and resonance continuum. The b_n-factors are computed, including the transfer problem in the subordinate lines and resonance continuum.

5969 INTERACTION OF A TRIPLET AND A NORMAL HELIUM ATOM.
G.H.Brigman, S.J.Brient and F.A.Matsen.

J. chem. Phys. (USA), Vol. 34, No. 3, 958-60 (March, 1961).

The electronic energy of the system $He(^1S)$ and $He(^3S)$ is calculated as a function of nuclear separation. This calculation differs from an earlier one by Buckingham and Dalgarno in three ways: (1) the use of a nodeless 2s function, (2) the use of an open-configuration wave function (1s1s') for $He(^1S)$ and (3) the use of orbital exponents optimized for each internuclear distance. The energy obtained lies approximately one volt below the earlier calculation but confirms it in all qualitative aspects including the presence of a "hump" at $R \cong 4a_0$.

5970 OSCILLATOR STRENGTHS OF LEAD AND THE LEA ABUNDANCE IN THE SUN.
T.M.Helliwell.

Astrophys. J. (USA), Vol. 133, No. 2, 566-71 (March, 1961).

The oscillator strengths of four transitions in neutral lead ha been calculated and compared with recent experimental results. method of calculation is described. These values are used to inve gate the problem of lead abundance in the sun, which is compared with the abundance predicted by the theory of stellar nucleosynthe

5971 OPTICAL HYPERFINE STRUCTURE AND NUCLEAR MOMENTS OF PROMETHIUM 147.
P.F.A.Klinkenberg and F.S.Tomkins.

Physica (Netherlands), Vol. 26, No. 2, 103-14 (Feb., 1960).

The hyperfine structure of a number of Pm I and Pm II lines measured. From the best-resolved patterns it is derived that the ground state spin of the Pm^{147} nuclide is 7/2. On plausible assum tions concerning the electronic level scheme of Pm II the value of the nuclear magnetic moment turns out to be 2.7 nuclear magneto with an estimated uncertainty of ±10%. The nuclear electric quadrupole moment is small. The results are discussed on connection with the nuclear shell model and radioactive decay data.

5972 TERM REPRESENTATION OF THE K-SERIES OF X-RAY SPECTRA.
A.Dziwoki.

Ann. Phys. (Germany), Vol. 7, No. 1-2, 84-111 (1961). In German

The K-terms of X-ray spectra are given as a sum of three parts, E_n, E_l, E_s, characterized by the quantum numbers n, l, an using the relation previously given by the author [Ann. Phys. (Germany), Vol. 43, 579-97 (1943)]. Expressions for the energy quanta E_n and E_s are well-known; an explicit expression is given f E_l.

W.J.Orville-Tho

5973 MEASUREMENT OF THE OSCILLATOR STRENGTH f OF BARIUM LINES.
Yu.I.Ostrovskii and N.P.Penk

Optika i Spektrosk. (USSR), Vol. 9, No. 6, 703-6 (Dec., 1960). In Russian.

The Rozhdestvenskii "hooks" method was used to measure th relative oscillator strengths of 65 Ba I lines between 3889 and 79 A. The results agreed with those obtained by Kruithof (1943) and with theoretical predictions. [English translation in: Optics and Spectrosc. (USA), Vol. 9, No. 6, 371-3 (Dec., 1960)].

A.Tybulew

5974 ISOTOPE SHIFT IN THE ARC SPECTRUM OF NICKE
D.J.Schroeder and J.E.Mack.

Phys. Rev. (USA), Vol. 121, No. 6, 1726-31 (March 15, 1961).

The isotope shift in 31 spectral lines in the nickel arc spectr was determined by the use of a Fabry—Perot interferometer. Th normal mass shifts were calculated (≅ +0.025 cm^{-1} between Ni^{58} and Ni^{64}) and subtracted from the observed isotope shifts. The differences were attributed to the specific mass and field effects. The relative shifts of levels of four configurations were deduced from the observed line shifts, these being the "complex" configur tions $3d^84s^2$ and $3d^84s4p$ and the two-electron configurations $3d^94$ and $3d^94p$. It was shown that the shifts due to the specific mass effect are a significant part of the observed shifts. Perturbation due to interconfiguration interactions were postulated to explain some of the observed shifts. The isotope shift to be expected between Ni^{58} and Ni^{64} on the basis of field effect calculations is about -0.02 cm^{-1} for a single 4s electron, while the shifts observ are as large as $+0.190$ cm^{-1}. A large fraction of this shift must therefore be attributed to the specific mass effect. By noting the deviations of the relative shifts between adjacent pairs of even isotopes from those predicted by mass effect theory, it was possi to deduce the relative field effect. The relative level shift resulti from the field effect is nearly the same for the adjacent isotope pairs 60-62 and 62-64 while the relative level shift for the isotop pair 58-60 is approximately 0.004 cm^{-1} larger than that for the other adjacent isotope pairs. The arrangement of neutrons in the outermost nuclear shells is believed to account for this differenc Within the experimental error the level shift of the Ni^{61} relative to the neighbouring even isotopes is such that there is no odd—ev staggering of the levels.

5975 ISOTOPE SHIFTS IN PALLADIUM.

R.H.Hughes and F.A.Sharpton.

hys. Rev. (USA), Vol. 121, No. 6, 1702-3 (March 15, 1961).

Isotope shifts in the $4d^9 5s\,^1D_2 - 4d^9 5p\,^3F_3^\circ$ transition at λ4212 A
 the first spectrum of Pd were studied using enriched isotopes.
he shifts are similar to those found by Kuhn and Warner (1958)
 the $4d^9 5s\,^3D_3 - 4d^9 5p\,^3F_4^\circ$ transition at λ3405 A. The most interesting feature is the maximum in the isotope shift which appears at
e neutron number pair 60-58.

5976 THE ABSOLUTE f-VALUE OF THE Pb I LINE λ 2833.

G.D.Bell and R.B.King.

strophys. J. (USA), Vol. 133, No. 2, 718-22 (March, 1961).

The absolute f-value of the Pb I line λ 2833 absorbed from the
round state $6p^2\,^3P_0$ was measured by the atomic-beam technique.
The absolute f-value was found to be 0.23, in good agreement with
he result of a recent theoretical investigation.

5977 LOW EVEN CONFIGURATIONS IN THE FIRST SPECTRUM OF THORIUM (Th I).

R.E.Trees.

hysica (Netherlands), Vol. 26, No. 5, 353-60 (May, 1960).

Positions of twenty-one observed levels in the $6d^2\,7s^2$ and
d^3 7s configurations of Th I are calculated with a mean error of
 143 cm^{-1}, by use of seven adjustable parameters. This mean
rror is reduced to ±47 cm^{-1} by use of the L(L + I) correction in a
alculation with eleven adjustable parameters. The agreement
etween observed and calculated g-values is satisfactory. The
arameters are compared with ones already published for related
onfigurations in the spectra of Th II and Th III. With one exception,
imilarly defined parameters show a roughly linear variation with
e degree of ionization, in accordance with simple expectation. The
ffect of neglecting the $6d^4$ configuration in Th I is briefly discussed
 explain this exception.

5978 MOTT POLARIZATION IN SCATTERING OF ELECTRONS FROM THOMAS–FERMI AND HARTREE TOMS.

T.Tietz.

cta phys. Hungar., Vol. 12, No. 2, 151-62 (1960). In German.

The effect of the electron structure of the scattering atoms on
e Mott polarization of doubly scattered electrons is investigated.
artree and Thomas–Fermi potentials are considered in detail,
d expressions for the intensity distribution of the scattered
lectrons are obtained by use of the Born–Dirac collision formalism
 the Sauter representation. Numerical examples are cited.

P.M.Parker

5979 CALCULATION OF THE CHARACTERISTICS OF INELASTIC SCATTERING OF MEDIUM-ENERGY LECTRONS.

A.N.Pilyankevich.

h. tekh. Fiz. (USSR), Vol. 31, No. 2, 224-30 (Feb., 1961). In
ussian.

It is shown that inclusion of the exchange effects in the formula
r inelastic electron scattering on isolated atoms leads to a decrease of the differential and the total cross-sections of the process.
his effect is studied quantitatively using Born approximation with
 view to applications in electron microscopy. [English translation
: Soviet Physics–Technical Physics (USA)].

F.Herbut

5980 THE CONTRIBUTION OF OCTUPOLE FORCES TO VAN DER WAALS ATTRACTION.

F.Berencz.

cta phys. Hungar., Vol. 12, No. 2, 103-6 (1960). In German.

The author uses the expression derived in a previous paper
Abstr. 884 of 1961) to investigate the interaction between two
elium atoms. It is found that the dipole–octupole interaction
nergy is of the same order of magnitude as the dipole–quadrupole
nergy and hence both interaction terms must be taken into account
r neglected in any theoretical calculations.

W.J.Orville-Thomas

5981 THE ENERGY TRANSFERRED IN INELASTIC ION–ATOM COLLISIONS.

J.B.Hasted.

roc. Phys. Soc. (GB), Vol. 77, Pt 2, 269-72 (Feb., 1961).

Multiply-charged target ion abundances for Ne^+–A 75 keV
ollisions are calculated from the theory of Russek and Thomas
Abstr. 8846 of 1958) and compared with experimental data of
frosimov and Fedorenko [Abstr. 5841 of 1959; Zh. tekh. Fiz.(USSR),
ol. 27, 1573 (1957)]. The electron energy distribution for "hard
cattering" is also calculated, and shows a maximum at about 200 eV.

5982 THE COLLIMATION OF ATOMIC BEAMS.

I.Agîrbiceanu, V.Drăgănescu and A.Chetroiu.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 247-56 (1959).
In Roumanian.

The collimation of an atomic beam is critically dependent on the slit width used. For larger or smaller slit widths the collimation is unsatisfactory. In calculating the value of the Doppler half-width, for the lamp used, it is found that $\delta\nu = 8 \times 10^{-4}$ cm^{-1}, corresponding to an absolute temperature of 4.3°K.

T.E.Peacock

5983 EVIDENCE OF MULTIPLE TRAPPING SITES FOR EXCITED NITROGEN ATOMS IN SOLID MOLECULAR NITROGEN.

R.A.Hemstreet and J.R.Hamilton.

J. chem. Phys. (USA), Vol. 34, No. 3, 948-57 (March, 1961).

A study of glow curves and thermal effects indicates that both ground state and excited nitrogen atoms are trapped in discharged nitrogen condensed at 4.2°K. At elevated temperatures the recombination of ground state atoms is apparently governed by a single activation energy. The excited atoms are found in two types of traps; one associated with the ordered and the other with the disordered regions in the matrix and each has a distribution of energies.

Isotopes

5984 PRODUCTION OF VERY HIGH PURITY ISOTOPES BY A DOUBLE MAGNETIC DEFLECTION ISOTOPE SEPARATOR.

R.Bernas, J.L.Sarrouy and J.Camplan.

Rev. sci. Instrum. (USA), Vol. 32, No. 1, 96-7 (Jan., 1961).

The first stage is a 60° homogeneous magnetic sector with a mean radius of 50 cm. The second stage is a 180° inhomogeneous field of cylindrical symmetry with $H_r = H_{ro}(r_o/r)^n$ with $n = 0.48$ and $r_o = 400$ mm. Typical results are given. The separation of radioactive isotopes with half lives as short as 1 minute has been achieved.

J.W.Sturgess

5985 FRACTIONATION OF NITROGEN ISOTOPES BETWEEN NITROSONIUM SALT SOLUTIONS AND NITROGEN OXIDES.

A.Narten.

J. chem. Phys. (USA), Vol. 34, No. 3, 1056-7 (March, 1961).

Single stage enrichment factors α for the isotope exchange reaction of N^{15} between oxides of nitrogen and solutions of nitrosylsulphuric and nitrosylphosphoric acid were determined. Single stage equilibration resulted in values of α that decrease from 1.046 for 1M to 1.013 for 10.2M sulphuric acid in the nitrosylsulphuric acid system, and from 1.043 for 4.7M to 1.005 for 14.8M phosphoric acid in the nitrosylphosphoric acid system.

5986 THE HIGH-PRECISION ISOTOPIC ANALYSIS OF URANIUM HEXAFLUORIDE.

J.Bishop, D.F.Davidson, P.B.F.Evans, A.N.Hamer, J.A.McKnight and E.J.Robins.

J. sci. Instrum. (GB), Vol. 38, No. 4, 109-18 (April, 1961).

A description is given of a 90° sector field mass spectrometer of 30 cm radius, which was built and used to investigate the accuracy which can be achieved in UF_6 isotopic analysis. The precision (1 σ) of this instrument when measuring the fractional difference in isotope ratio between two samples is 5×10^{-5} at the 50% level of enrichment and 1.4×10^{-4} with natural uranium, for comparisons lasting 12 minutes. By suitable design of ion source and inlet system, the memory error in the measurement of the concentration difference between two samples has been reduced to ±0.3% of the difference.

5987 NATURAL OCCURRENCE OF SAMARIUM-146.

R.D.Macfarlane.

Nature (GB), Vol. 188, 1180-1 (Dec. 31, 1960).

Reports measurements which set an upper limit on the occurrence of Sm^{146} in ordinary samarium of 2×10^{-7}%.

R.H.Thomas

ISOTOPE EFFECT IN INTERMETALLIC DIFFUSION.
See Abstr. 4993

Mesic Atoms

5988 INVESTIGATION OF THE PARAMAGNETISM OF μ-MESIC ATOMS.

L.B.Egorov, G.V.Zhuravlev, A.E.Ignatenko, Li Syuang-Ming, M.G.Petrashku and D.Chultem.

Nuclear Phys. (Internat.), Vol. 23, No.1, 62-74 (Feb., 1961).

The nature of the paramagnetism of various mesic atoms is investigated by measuring the asymmetry of μ—e decay electrons. The results of the experiments indicate that paramagnetism of mesic atoms in dielectrics and diamagnetic and weakly paramagnetic normal metals is due to the magnetic moment of the μ-meson. In paramagnetic transition metals, lanthanides and actinides it is due to the magnetic moments of the electron shell and the meson. It is demonstrated that polarized mesons can be used as a means for investigating the magnetic properties of atoms and hydrides of the transition metals, actinides and lanthanides with zero nuclear spins.

MUON DEPOLARIZATION IN MESIC ATOMS. See Abstr. 5746

MOLECULES

5989 MOLECULES AND MOLECULAR AND ATOMIC COMPLEXES AS GUIDES OF ELECTRONIC WAVES. A.P.Komar and A.A.Komar.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 231-7 (Feb., 1961). In Russian.

Presents an elementary macroscopic theory of the passage of electronic waves through molecules or molecular or atomic complexes, which is in general agreement with the well-known experimental results obtained with the help of electron projectors (emission microscopes). It is suggested that more detailed investigation of the intensity distribution in the "molecular waveguides" can lead to new information on the molecular structure, the internal potential etc. [English translation in: Soviet Physics—Technical Physics (USA)]. J.K.Skwirzynski

5990 TRANSFERABILITY OF UREY—BRADLEY FORCE CONSTANTS. VI. THE SILYL HALIDES.
J.Overend and J.R.Scherer.
J. chem. Phys. (USA), Vol. 34, No. 2, 574-7 (Feb., 1961).

For Pt V, see Abstr. 2313 of 1961. Urey—Bradley force constants are fitted, by least squares, to the observed vibrational frequencies of SiH_3F, SiH_3Cl, SiH_3Br, SiH_3I and their fully deuterated analogues. The force constants are correlated with other molecular parameters and, in the case of the nonbonded hydrogen—halogen repulsions, are discussed in terms of an inverse-power potential function.

5991 COEFFICIENTS OF INTERACTION BETWEEN VIBRATION AND ROTATION IN POLYATOMIC MOLECULES. II. L.Henry and G.Amat.
Cahiers de Phys. (France), Vol. 14, 230-56 (June, 1960). In French.

For Pt I, see Abstr. 3972 of 1959. The nonvanishing coefficients $\zeta_{S\sigma S'\sigma'}^{\alpha}$ (Coriolis coupling coefficients) and $a_{S\sigma}^{\alpha\beta}$ (variation coefficients of moments of inertia with respect to normal coordinates) are given for any asymmetric or axially symmetric molecule, and relations are established between these nonvanishing coefficients. By using standard rules for the orientation of the twofold degenerate normal coordinates it is possible to obtain the former relations in a general form for any molecule belonging to a given symmetry group.

5992 OPTICAL ROTATORY DISPERSION OF TRANSITION-METAL COMPLEXES. S.Sugano.
J. chem. Phys. (USA), Vol. 33, No. 6, 1883-4 (Dec., 1960).

Moffitt's explanation (Abstr. 3180 of 1957), for the optical rotatory dispersion of transition-metal complexes is criticized and the need for further studies on the vibronic mechanism emphasized. W.J.Orville-Thomas

5993 POWER SERIES EXPANSIONS OF VIBRATIONAL POTENTIALS. I. THE HEITLER—LONDON POTENTIAL FOR H_2. C.L.Beckel.
J. chem. Phys. (USA), Vol. 33, No. 6, 1885-6 (Dec., 1960).

Discusses results of expanding this potential in powers of $(r-r_e)/r_e$ in the range $0 < r < 2r_e$. J.Hawgood

5994 POWER SERIES EXPANSIONS OF VIBRATIONAL POTENTIALS. II. TWO CLASSICAL POTENTIALS FOR IONIC MOLECULES. E.J.Finn and C.L.Beckel.
J. chem. Phys. (USA), Vol. 33, No. 6, 1887-8 (Dec., 1960).

For Pt I, see preceding abstract. Potentials involving exponential repulsion terms and attraction terms in $1/r$ and $1/r^4$, (the latter in one potential only), were applied to alkali halides and to InF and InCl. The power series expansion seems useful, particularly when the $1/r^4$ is included in the potential. J.Hawgood

5995 ENERGY LEVELS FOR INTERNAL AND OVER-ALL ROTATION OF TWO-TOP MOLECULES. I. MICROWAVE SPECTRUM OF DIMETHYL SILANE. L.Pierce.
J. chem. Phys. (USA), Vol. 34, No. 2, 498-506 (Feb., 1961).

A method is given for analysing barrier-dependent "tunnel effect" splittings in rotational spectra of molecules with two equivalent tops. The perturbation treatment is an extension of the "principal axis" method for single-top molecules, and is limited to torsional states in which the two principal torsional quantum numbers are identical. Tables of perturbation coefficients are given from which the effects of top-top coupling on the rotational spectrum may be calculated. The microwave spectra of six isoto species of dimethyl silane have been investigated in the region 8 t 25 kMc/s. Changes in moments of inertia with isotopic substituti yield the following structural parameters:

SiC	1.867 ± 0.002 A	CSiC	110°59' ± 10'
SiH	1.483 ± 0.005 A	HSiH	107°50' ± 20'
CH	1.095 ± 0.005 A	HCH	108°0' ± 20'

$$2\theta = 110^\circ 59' \pm 1^\circ$$

where 2θ is the angle between the symmetry axes of the methyl groups. From splittings in the rotational spectrum the angle 2θ is found to be 110°59' ± 20'. Analysis of splittings for $(CH_3)_2SiH_2$, $(CH_3)_2SiD_2$, and $(CH_3)(CD_3)SiH_2$ indicates that coupling between top is very small. Assuming no coupling, the barrier to internal rotation is 1647 ± 3 cal/mole. From Stark effect measurements the dipole moment is found to be 0.75 ± 0.01D.

5996 NEW DETERMINATIONS OF THE VIBRATIONAL CONSTANTS OF Li^6F AND Li^6Cl^{35} BY THE MOLECULAR BEAM ELECTRIC RESONANCE METHOD.
T.I.Moran and J.W.Trischka.
J. chem. Phys. (USA), Vol. 34, No. 3, 923-8 (March, 1961).

New measurements of the vibrational constants of LiF and Li were stimulated by the hypothesis of Klemperer and Herschbach that disagreement between infrared and previous molecular beam values of these constants could be explained by a variation in the efficiency of the molecular beam detector with vibrational state. The new molecular beam results rule out this hypothesis because of their agreement with infrared results. These new values are 930 ± 19 cm^{-1} for Li^6F and 705 ± 14 cm^{-1} for Li^6Cl^{35}. The agreement of these values with the infrared results leads to the conclusion that the vibrational states of molecules in the molecular beam source have a Boltzmann distribution. The relative detector efficiency for the vibrational states $v = 0$ and $v = 1$ did not vary when the total efficiency was changed over a range from 0.2 of the maximum value to the maximum. The ratio of the vibrational constants of Li^6F and Li^7F was found to be 1.06 ± 0.01, in agreement with the value calculated from the ratio of the reduced masses. A rough measurement of the vibrational decay constant between the $v = 1$ and $v = 0$ states gave 65 ± 40 se

5997 SHOCK TUBE STUDY OF VIBRATIONAL RELAXATIO IN THE A $^2\Sigma+$ STATE OF NO. W.Roth.
J. chem. Phys. (USA), Vol. 34, No. 3, 999-1003 (March, 1961).

Nonequilibrium NO γ-band emission was observed behind inc shock waves in rare gas—air mixtures in the approximate temperature range, 5000-10 000°K. Vibrational relaxation times for collisional de-excitation of NO($A\,^2\Sigma^+$) were measured. The measu relaxation times were used to calculate P_{10}, the probability for collisional de-excitation of the $v' = 1$ level of the $A\,^2\Sigma+$ state; P_{10} ranges from about 3×10^{-5} at 5000°K to 3×10^{-4} at 10 000°K.

5998 ON THE POTENTIAL ENERGY CURVES OF CARBOXYLIC ACIDS. I.Cucurezeanu.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 2, 163-9 (1957). In Roumanian.

The theory of inversion doubling is shown not to apply to cycl dimers of carboxylic acids, and that their potential energy curves not present the two potential minima indicated by this theory. Because of the interpretation given in earlier work [Bulletin stiintifi Academia republicii populare române. Bucareşti, No. 1, 187 (1957 according to which the doublet 2990, 3020 cm^{-1} must belong to the CH_3 group and not to the O—H group of acetic acid, and because of the spectroscopic manifestations of the O—H group included in the hydrogen bond in the form of a broad band, the author shows that t dimers of carboxylic acids do not possess curves having two potential minima and that in consequence the H atom included in the O—H···O group of these dimers does not possess two positions of equilibrium. Finally, the author declares himself in agreement with he theory of Fuson and Josien (Abstr. 263 of 1954) on the existence f several positions of equilibrium of the H atom and consequently admits the existence of a potential energy curve with several non-dentical minima of different depths.

5999 COMPARISON OF THEORETICAL CALCULATIONS ON DIATOMIC MOLECULES WITH EXPERIMENT.

E.R.Davidson.

J. chem. Phys. (USA), Vol. 34, No. 4, 1240-42 (April, 1961).

A method for the numerical computation of the vibrational-rotational term levels from an arbitrary potential curve is presented. In this method, the potential curve is approximated by a step function and the exact eigenvalues of this latter function are ound by an iteration technique. The accuracy of this method is demonstrated by finding the term levels for a Morse potential and for the ground state of H_2.

6000 HARMONIC WAVE NUMBERS, ROTATIONAL DISTORTION CONSTANTS, AND THERMODYNAMIC PROPERTIES FOR PARTIALLY DEUTERATED AND TRITIATED MOLECULES OF THE TYPE XYZ_2 (X = N, P, OR As; Y, Z = H, D, OR T).

G.Thyagarajan, S.Sundaram and F.F.Cleveland.

J. molecular Spectrosc. (USA), Vol. 5, No. 4, 307-18 (Oct., 1960).

Using a harmonic potential energy function, the harmonic wave-numbers for partially deuterated and tritiated molecules of the type XYZ_2 (Z = N, P, or As; Y, Z = H, D, or T) were calculated by the Wilson FG matrix method. The rotational distortion constants for all these molecules were also calculated on the basis of the first-order perturbation theory of Kivelson and Wilson. Further, with the calculated wave-numbers, the molar thermodynamic properties were obtained for 12 temperatures between 100^0 and 1000^0 K for the ideal gaseous state at 1 atm pressure and for a rigid-rotor harmonic-oscillator approximation.

6001 THE VIBRATION—ROTATION ENERGIES OF TETRAHEDRAL XY_4 MOLECULES. I. THEORY OF SPHERICAL TOP MOLECULES.

K.T.Hecht.

J. molecular Spectrosc. (USA), Vol. 5, No. 5, 355-89 (Nov., 1960).

The theory of vibration—rotational perturbations in tetrahedral XY_4 molecules is reexamined in the light of the modern theory of angular momentum coupling. It is shown that, even to third order of approximation, the splitting of a vibration-rotation level into its tetrahedral sublevels is governed only by perturbation terms of one basic symmetry in all states in which vibrational quanta of ν_1, ν_3 and ν_4 are excited and to a certain approximation in many of the infrared-active states in which quanta of both ν_2 and ν_3 or ν_4 are excited. The perturbation term is identified as the tetrahedrally symmetric linear combination of fourth-rank spherical tensor operators. In dominant approximation the rotational fine structure splitting patterns are characterized solely by the rotational angular momentum of the state. Only the overall extent of the patterns depends on the vibrational and total angular momentum quantum numbers and the vibrational character of the state. In next approximation the basic splitting patterns are all deformed to a certain extent by matrix elements off-diagonal in the rotational angular momentum quantum number. These cannot be neglected if theory is to account for the modern high resolution-spectra. The terms of the vibration—rotation Hamiltonian to third order of approximation are classified according to their symmetry. Explicit expressions are given for the pure vibrational energies of the simpler bands. Explicit numerical values are also given for the matrix elements of the rotational sublevels of types A_1, A_2, E, F_1 and F_2 from which the rotational energies of the vibrational ground state and the infrared-active fundamentals can be computed. These matrix elements also give the numbers for the basic splitting patterns of the dominant approximation for any state involving combinations of ν_1, ν_3 and ν_4.

6002 VIBRATION—ROTATION ENERGIES OF TETRAHEDRAL XY_4 MOLECULES II. THE FUNDAMENTAL ν_3 OF CH_4.

K.T.Hecht.

J. molecular spectrosc. (USA), Vol. 5, No. 5, 390-404 (Nov., 1960).

The matrix elements derived in Pt I (preceding abstract) are sed to compute the frequencies of the tetrahedral fine-structure omponents of the rotational lines of the fundamental ν_3 of CH_4. The heoretically predicted frequencies are compared with the recent igh-resolution spectra of Plyler et al. (Abstr. 15735 of 1960). A est fit for the splitting patterns is obtained with the following plitting constants: $t_{224} = -2.93 \times 10^{-3}$ cm^{-1}, $t_{134} = -4.5 \times 10^{-6}$ cm^{-1}, $t_{244} = -5.0 \times 10^{-6}$ cm^{-1}. Analysis of the unperturbed frequency positions and the weak forbidden P and R branch lines gives the following rotational constants: $B_0 = 5.240$ cm^{-1}, $D_S = 1.0 \times 10^{-4}$ cm^{-1}, $B_3(R = J) = 5.191$ cm^{-1}, $B_3(R = J + 1, J - 1) = 5.201$ cm^{-1}, $\zeta_3 = 0.054_7$.

6003 ROTATIONAL ANALYSIS OF THE ABSORPTION SPECTRUM OF CARBON MONOSULPHIDE.

R.F.Barrow, R.N.Dixon, A.Lagerqvist and C.V.Wright.

Ark. Fys. (Sweden), Vol. 18, Paper 38, 543-62 (1960).

A study was made of the rotational structure in the ultraviolet absorption spectrum of carbon monosulphide, produced by flash photolysis of carbon disulphide. The bands observed consist of the 0-0, 1-0 and 2-0 bands of the $A^1\Pi$-$X^1\Sigma^+$ system, three bands of a new system, $a^*(\Pi)$-$X^1\Sigma^+$, and also bands of two forbidden systems, $a'\,^3\Sigma^+$, $e\,^3\Sigma^-$-$X^1\Sigma^+$. The presence of these excited states had earlier been inferred from the analysis of perturbations in the $A^1\Pi$-$X^1\Sigma^+$ system as observed in emission: however the direct observation of lines arising from the forbidden transitions in absorption provides a unique opportunity of testing the theory of the mutual interaction of molecular states. The $a'\,^3\Sigma^+$, $A^1\Pi$ perturbation shows detailed agreement with theoretical predictions: some unsolved problems in the $e\,^3\Sigma^-$, $A^1\Pi$ interaction remain.

6004 ELECTROCHROMISM, A POSSIBLE CHANGE OF COLOR PRODUCIBLE IN DYES BY AN ELECTRIC FIELD.

J.R.Platt.

J. chem. Phys. (USA), Vol. 34, No. 3, 862-3 (March, 1961).

Theoretical considerations suggest that the absorption and emission spectra of certain dyes may be shifted by hundreds of angstroms upon application of a strong electric field. The effect could be called "electrochromism", in analogy to "thermochromism" and "photochromism". The theory of the effect is outlined and is discussed in terms of compounds which might be expected to show it most strongly.

6005 MICROWAVE SPECTRUM OF ACETYL CHLORIDE.

K.M.Sinnott.

J. chem. Phys. (USA), Vol. 34, No. 3, 851-61 (March, 1961).

The microwave spectrum of ten isotopic species of acetyl chloride are reported. Internal rotation of the methyl group splits some of the rotational transitions into doublets in addition to the chlorine hyperfine structure. Analysis of the internal rotation splitting gives a barrier to internal rotation of 1296 ± 30 cal/mole. From the hyperfine structure, the chlorine nuclear quadrupole coupling constants for Cl^{35} along the C—Cl bond axis and perpendicular to the plane of symmetry of the molecule were determined to be −58.5 and 21.5 Mc/s, respectively. The corresponding values for Cl^{37} were −46.4 and 17.2 Mc/s. These coupling constants are interpreted to give information about the double bond and ionic character of the C—Cl bond. The following structural parameters were determined from the rotational constants of CH_3COCl^{35}, CH_3COCl^{37}, $C^{13}H_3COCl^{35}$, $CH_3C^{13}OCl^{35}$, $CH_3CO^{18}Cl^{35}$, and CD_3COCl^{35}:

C—H	1.083 ± 0.005 A	<CCH	$110^0 21' \pm 10'$
C—C	1.499 ± 0.010	<CCO	$127^0 5' \pm 10'$
C=O	1.192 ± 0.010	<CCCl	$112^0 39' \pm 30'$
C—Cl	1.789 ± 0.005		

The observed rotational constants of CH_2DCOCl^{35} show that the equilibrium configuration of acetyl chloride has a methyl hydrogen atom opposite the oxygen atom.

6006 LINE BREADTHS IN THE AMMONIA SPECTRUM.

J.A.Fulford.

Nature (GB), Vol. 188, 1097-8 (Dec. 24, 1960).

A preliminary report is given of intensity measurements of improved accuracy for the lines in the ammonia inversion spectrum for which J = K = 1 to 6 inclusive. Peak absorption coefficients are determined with stated accuracies of 0.7 to 5%. On the assumption that the collision broadening coefficient per unit pressure varies as $K/\sqrt{J(J+1)}$, the peak intensities fit the Van Vleck—Weisskopf relationship with a collision broadening coefficient for the J = K = 3 line of 25.7 ± 0.2 Mc/s per mm Hg at 27^0C.

J.Sheridan

6007 MILIMETER WAVE SPECTRUM AND MOLECULAR STRUCTURE OF OXYGEN DIFLUORIDE.

A.R.Hilton, Jr, A.W.Jache, J.B.Beal, Jr, W.D.Henderson and R.J.Robinson.

J. chem. Phys. (USA), Vol. 34, No. 4, 137-41 (April, 1961).

A video microwave spectrometer was used to find 13 rotational absorption lines. Klystron-driven crystal harmonic generators were used as energy sources for the spectrometer. The frequencies of the lines were measured with a precise frequency standard. Nine of the lines were assigned to rotational transitions of OF_2 using a graphical method. The three average rotational constants, A, B, and C were determined from the exact energy solutions for the rotational transitions. The values for the rotational constants together with the effective moments of inertia calculated from them were A = 61 567.71 Mc/s, I_A = 8.21096 a.m.u., A^2; B = 11 066.54 Mc/s, I_B = 45.6809; C = 9 343.85 Mc/s; I_C = 54.1088 a.m.u., A^2. The effective values for the oxygen fluorine interatomic distance and the apex angle 2θ calculated from I_A and I_B were r = 1.3896 A, 2θ = 104.163. The rotational inertial defect was found to be +0.217 a.m.u., A^2.

6008 MICROWAVE SPECTRUM, STRUCTURE, DIPOLE MOMENT, AND INTERNAL BARRIER OF VINYL SILANE.

J.M.O'Reilly and L.Pierce.
J. chem. Phys. (USA), Vol. 34, No. 4, 1176-81 (April, 1961).

The structure of vinyl silane was determined by studying the microwave spectra of each of its single substituted isotopic species. Using Kraitchman's equations the following structural parameters were calculated:

C=C	1.347 A	Si—C=C	122°53'
Si—H	1.475	H—Si—H	108°42'
C—H (cis)	1.097	C=C—H (cis)	120°18'
C—H (trans)	1.097 (assumed)	C=C—H (trans)	120°38'
C—H	1.094	C=C—H	117°59'
Si—C	1.853		

By studying the isotopic species containing an asymmetric silyl group the equilibrium conformation was found to be staggered, i.e., the silyl hydrogens are staggered with respect to the hydrogen on the central carbon. The symmetry axis of the silyl group was found to be tilted by an angle of 1°49' from the Si—C bond axis towards the double bond. Comparison of the Si—C bond distance of vinyl silane with that of methyl silane indicates that recent estimates of the effect of changes in hybridization on the covalent radius of carbon are much too large. The barrier to internal rotation for vinyl silane was calculated from splittings of ground-state rotational transitions of SiH_3CHCH_2 and splittings of first-excited state transitions of SiH_3CHCH_2 and SiD_3CHCH_2, and also from Stark effect measurements on the K = 1, J = 2 ← 1 transitions of SiH_3CHCH_2. The various calculations are all in good agreement, and the best value for the barrier is found to be 1500 ± 30 cal/mole. Quadratic Stark effect measurements on the J = 2 ← 1 transitions gave μ_a = 0.648 D, μ_b = 0.133 D, and μ = 0.66 D. The resultant dipole moment makes an angle of 11 ± 2° with the a axis of SiH_3CHCH_2.

6009 MILLIMETRE WAVE SPECTRUM OF DEUTERO-DERIVATIVES OF FORMIC ACID.

A.M.Mirri.
Nuovo Cimento (Italy), Vol. 18, No. 5, 847-55 (Dec. 1, 1960).

The rotational constant A of DCOOH, HCOOD and DCOOD have been determined by analysing the "a" type transitions in the range of frequencies from 120 000 to 160 000 Mc/s. By assuming I_a and I_b as the equilibrium moments of inertia, the Kraitchman's method is used to determine the coordinates of the two hydrogen atoms in the principal axis system of HCOOH. The centrifugal distortion constants of the three molecules are also given.

6010 INFRARED SPECTROSCOPIC EVIDENCE FOR THE ROTATION OF THE AMMONIA MOLECULE IN SOLID ARGON AND NITROGEN.

D.E.Milligan, R.M.Hexter and K.Dressler.
J. chem. Phys. (USA), Vol. 34, No. 3, 1009-12 (March, 1961).

High-resolution infrared spectra (of the symmetric bending mode) of ammonia suspended at high dilution in solid argon and nitrogen were obtained. More than a half dozen extremely sharp bands were observed in the 950-1040 cm^{-1} region (in the spectrum of ammonia) in these materials under conditions where there should be little if any absorption due to polymeric species. The frequency separations of the bands, their temperature dependence, and their extreme sharpness appear to be compatible with a model in which the ammonia molecule executes quantized rotation in these solids.

6011 WIDE ABSORPTION BANDS ON THE INFRARED SPECTRA OF ADSORBED MOLECULES.

L.M.Roev.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 3, 561-3 (July 21, 1960). In Russian.

For abstract, see Abstr. 840 of 1961. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 805-7 (Jan.-Feb., 1961)].

6012 CALCULATED BAND INTENSITIES FOR CO_2 FROM INFRARED DISPERSION DATA.

B.Schurin.
J. chem. Phys. (USA), Vol. 33, No. 6, 1878-9 (Dec., 1960).

An alternative set of intensities of the CO_2 fundamental bands i obtained by recalculation from data of Wetterblad (1924). The valu for the 15 μ band (240 ± 5 cm^{-2} atm^{-1}) is in complete agreement with the most recent absorption measurements while that for the 4.27 μ band (2970 ± 60 cm^{-2} atm^{-1}) is 10% higher than previously reported.

R.C.Seymou

6013 INFRARED SPECTRA OF ALKYLDIBORANES. IV. 1,1-DIMETHYL- AND 1,1-DIETHYLDIBORANES.

W.J.Lehmann, C.O.Wilson, Jr and I.Shapiro.
J. chem. Phys. (USA), Vol. 34, No. 2, 476-83 (Feb., 1961).

For Pt III, see Abstr. 20634 of 1960. The infrared spectra of five isotopic variants of two, 1,1-dialkyldiboranes, viz., $(CH_3)_2B_2^{10}$ $(CH_3)_2B_2H_4$, $(CH_3)_2B_2D_4$, $(CD_3)_2B_2H_4$, and $(CD_3)_2B_2D_4$, and the corresponding diethyl compounds, are reported and frequency assignment are made. A method for purification of these compounds also is described. The intensity ratio of the 923 to 2096 cm^{-1} bands in $(CH_3)_2B_2H_4$ served as a simple preliminary criterion for the absen of other alkyldiboranes. The strong bridge-stretching frequencie of the 1,1-dialkyldiboranes at 1550 cm^{-1} are unique in being ~ 50 c lower than corresponding B—H' bands in other alkyldiboranes. Another B—H' absorption, at 2100 cm^{-1}, is quite intense compared with other alkyldiboranes.

6014 INFRARED SPECTRA OF ALKYLDIBORANES. V. TR AND TETRAMETHYL- AND ETHYLDIBORANES.

W.J.Lehmann, C.O.Wilson, Jr and I.Shapiro.
J. chem. Phys. (USA), Vol. 34, No. 3, 783-93 (March, 1961).

For Pt IV, see Abstr. 6739 of 1959. Frequency assignments a reported for the infrared spectra of tri- and tetramethyl- and ethyldiboranes, together with some of their boron-deuterated and B^{10} isotopic derivatives. Additionally, a Raman spectrum of tetramethyldiborane from sources in the literature is analysed. In assigning some of the B—C stretching frequencies, use is made of the recently formulated Average Rule.

6015 INTENSITIES OF INFRARED BANDS OF SOME I_2—ALKYLBENZENE CHARGE-TRANSFER COMPLEXES

E.E.Ferguson and I.Y.Chang.
J. chem. Phys. (USA), Vol. 34, No. 2, 628-31 (Feb., 1961).

The intensities of the infrared bands corresponding to symmetric ring breathing and symmetric methyl stretching modes were measured for charge-transfer complexes of iodine in benzene, toluene, the xylenes, mesitylene and 1,2,4 trimethylbenzene, duren penta-, and hexamethylbenzene. The ring breathing mode intensity is found to decrease and the methyl stretching mode intensity to increase with methyl substitution. These results are interpreted i terms of a previously proposed "electron vibration" infrared abso tion mechanism (Abstr. 1287 of 1959) extended to include π-electr interaction with methyl group electrons.

6016 NORMAL COORDINATE TREATMENTS AND CALCULATED THERMODYNAMIC PROPERTIES OF PHOSPHORYL CHLORIDE, THIOPHOSPHORYL CHLORIDE, AND PHOSPHORYL FLUORIDE.

J.S.Ziomek and E.A.Piotrowski.
J. chem. Phys. (USA), Vol. 34, No. 4, 1087-93 (April, 1961).

The infrared and Raman spectra for phosphoryl chloride, thiophosphoryl chloride, and phosphoryl fluoride were collected an examined for the most probable values for the wave numbers, intensities, and depolarization factors. The data are as follows: The Raman displacements $\Delta\sigma$ in cm^{-1}, the relative intensities I, an the depolarization factors ρ are for $POCL_3$: $\Delta\sigma(1)\rho$ = 192.85 (8) 0.83, 267.39 (6) 0.64, 337.44 (7) 0.81, 486.24 (10) 0.05, 581.2 (3) 6/ and 1289.9 (5) 0.04; for $PSCl_3$: 172 (5) 6/7, 247 (7) 6/7, 247 (calculated) 430 (10) 0.1, 538 (1) 6/7, and 753 (1) P; and for POF_3: 337 (w) 6/7, 476 (m) 6/7, 483 (from infrared) P, 875 (s) 0.05, 982 (vw) 6/7, and 1395 (m) 0.1. As for the infrared spectral data, thos of Cilento et al., were used for $PSCl_3$, and those of Gutowsky and Liehr were used for POF_3. No published infrared spectral data were found for $POCl_3$. Also normal coordinate treatments were conducted for $POCl_3$, $PSCl_3$, POF_3, and PSF_3 on the basis of a mod having C_{3V} symmetry. The normal coordinate treatments gave the listed wave-numbers as fundamentals and lend support for the 247 cm^{-1} band for $PSCl_3$ and 483 cm^{-1} band (observed in the infrar and assigned as fundamental by Gutowsky and Liehr) for POF_3 as the missing Raman bands. Moreover, the F matrix elements obtained for these molecules were determined in such a manner th those potential constants for the PCl_3 group had nearly the same values in both $POCl_3$ and $PSCl_3$, those for the PF_3 group had nearly the same values in both POF_3 and PSF_3 the one for the PO group had nearly the same value in both $POCl_3$ and POF_3 and the one for the PS group had nearly the same value in both PSF_3 and $PSCl_3$. The potential constants determined had the following values in md/A: For $POCl_3$, $f_{PO} = 9.890$, $f_{PCl} = 2.466$, $f_{PClPCl} = 0.399$, for $PSCl_3$, $f_{PS} = 0.030$, $f_{PCl} = 2.466$, $f_{PClPCl} = 0.399$; for POF_3, $f_{PO} = 9.890$, $f_{PF} = 5.633$, $f_{PFPF} = 0.483$, and for PSF_3, $f_{PS} = 2.9694$, $f_{PF} = 2.9694$, $f_{PF} = 5.333$, $f_{PFPF} = 0.183$. Finally, the values of the thermodynamic properties for these substances were computed for the ideal gaseous state using the rigid rotor harmonic oscillator approximation at 1 atm from 200° to 1000°K.

6017

SPECTRA OF AROMATIC NITROSODERIVATIVES.

D.Bîrcă-Gălăţeanu, L.Arcan and C.Lupu.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 417-27 (1959). In Roumanian.

Para-nitrosodimethylanilene and α-nitro-β-naphthol in the solid state and in solutions of CS_2 and CCl_4 were examined in the 700-1700 cm^{-1} region. The presence of both the monomeric and dimeric forms is indicated. The NO fundamental band lies between 1490 and 1630 cm^{-1} for the monomer and about 100 cm^{-1} less for the dimer. The stretching frequency of the R-N=O group is approximately half the NO fundamental frequency. Also the C—N band lies between 1070 and 1250 cm^{-1} for the monomer and is less than 1000 cm^{-1} for the dimer.

D.L.Greenaway

6018

THE RAMAN SPECTRUM OF METHANE-d_4.

R.A.Olafson, M.A.Thomas and H.L.Welsh.

Canad. J. Phys., Vol. 39, No. 3, 419-36 (March, 1961).

The Raman spectrum of CD_4 at 1 atm pressure was photographed with a spectral resolution of ~0.4 cm^{-1}, and rotational analyses of the ν_2 and ν_3 bands were carried out. The B_0 values obtained from the ν_2 and ν_3 bands are 2.6330 ± 0.007 and 2.6328 ± 0.0007 cm^{-1}, respectively; the value of r_0 determined from the former is 1.09181 ± 0.00029 A. The rotational levels of the v = 1 state of ν_2 are split with effective B_1 values equal to 2.6894 2.7351, and 2.7434 cm^{-1}. Thirteen of the fifteen branches of the ν_3 band were observed; these also show multiple B_1 values. The value obtained for ζ_3 is 0.1648. Structure was observed but not analysed in the ν_1, $2\nu_4$, and $\nu_2 + \nu_4$ bands. On the basis of the Raman data the structures of the ν_2 and ν_3 infrared bands are discussed.

6019

THE RAMAN SPECTRUM OF GASEOUS CF_4.

B.Monostori and A.Weber.

J. chem. Phys. (USA), Vol. 33, No. 6, 1867-8 (Dec., 1960).

Positions of vibrational lines together with their rotational structures are tabulated. The evaluation of Coriolis coupling coefficients is discussed.

G.F.Lothian

6020

THE EFFECT OF HYDROGEN BONDING ON THE INTENSITY OF THE CD RAMAN BAND OF $CDCl_3$.

D.G.Rea.

J. chem. Phys. (USA), Vol. 33, No. 6, 1875-6 (Dec., 1960).

Measurements of the CD stretching vibration were made on $CDCl_3$ and on 10% solutions in 10 different solvents. Band positions and widths correspond with those for infrared absorption; the band intensity is approximately the same for pure compound and for the solutions, whereas in the infrared the intensity is much greater for solutions.

G.F.Lothian

6021

SPECTROSCOPIC STUDY OF THE AFTERGLOWS OF N_2 AND $(N_2 + O_2)$ IN THE VACUUM REGION.

Y.Tanaka, A.S.Jursa, F.J.LeBlanc and E.C.Y.Inn.

Planet. Space Sci. (GB), Vol. 1, No. 1, 7-13 (Jan., 1959).

Four different stages of afterglow can be observed when the O_2 partial pressure in a mixture of N_2 and O_2 is changed. A study was made of the relationship between the partial pressures of N_2 and O_2 for each individual stage. The absorption spectra of these glows in the vacuum region showed the presence of N, O, and NO, and measurements were made of the concentration of atomic nitrogen, $2p^{3\,4}S$, $2p^{3\,2}D$, $2p^{3\,2}P$, in the nitrogen afterglow. The $a^1\Pi_g - X^1\Sigma_g^+$ bands of N_2 were observed in emission in the nitrogen afterglow. With consideration of both emission and absorption spectra, the reaction mechanisms are discussed briefly for each stage.

6022

A SHORT DURATION AFTERGLOW OF NITROGEN; SURVEY OF AFTERGLOWS.

O.Oldenberg.

Planet. Space Sci. (GB), Vol. 1, No. 1, 40-2 (Jan., 1959).

When an electron beam of more than 10.5 eV energy traverses low pressure nitrogen the beam is surrounded by a diffuse glow emitting the first positive bands. This light is interpreted as an afterglow. It is attributed to metastable molecues, $a^1\Pi$, which diffuse out of the space occupied by the beam, are thrown by collisions with normal molecules into the unstable state $B^3\Pi$ and then emit the first positive bands. The time required for diffusion is of the order 5×10^{-5} sec. This afterglow is compared with four other types of nitrogen afterglow.

6023

THE ULTRAVIOLET SPECTRUM OF TRIPTYCENE.

C.F.Wilcox, Jr.

J. chem. Phys. (USA), Vol. 33, No. 6, 1874-5 (Dec., 1960).

The spectrum of triptycene was calculated using a simple model. This treats π-electron transitions of coupled chromophores in terms of local and charge transfer excitation. The other assumptions made are those usually used in Pariser—Parr type calculations. The calculation provides a gross interpretation of the observed spectrum but fails to account for the 0.1 eV bathochromic shift of the α-band and its enhanced absorption when compared with barylene.

T.E.Peacock

6024

VACUUM ULTRAVIOLET ABSORPTION SPECTRUM AND DIPOLE MOMENT OF NITROGEN TRIFLUORIDE.

S.R.La Paglia and A.B.F.Duncan.

J. chem. Phys. (USA), Vol. 34, No. 3, 1003-8 (March, 1961).

The electronic absorption spectrum of NF_3 was investigated for the first time. At the lowest pressures, the long wavelength limit of absorption is at about 960 A in agreement with the lowest ionization potential of the molecule (939 A). Quantitative intensity measurements showed a smooth decrease of the absorption coefficients to effectively zero at about 1800 A, with no indication of even partly resolved electronic transitions. Comparisons with the electronic spectrum of ammonia are discussed. The molecular dipole moment is used to obtain an equivalent orbital representation of the NF_3 wave-function.

6025

ULTRA-VIOLET ABSORPTION SPECTRUM OF WATER.

R.M.Golding.

Nature (GB), Vol. 189, 132 (Jan. 14, 1961).

Some of the absorption peaks in the u.v. spectrum of water recently discussed (Abstr. 15736 of 1960) are shown to be inherent in the experimental technique used.

G.I.W.Llewelyn

6026

THE BIRADICAL PARADOX.

H.M.McConnell.

J. chem. Phys. (USA), Vol. 33, No. 6, 1868-9 (Dec., 1960).

A possible explanation is put forward for the apparent paradox between the experimental indications that the ground-state singlet—triplet splittings in large biradicals are small compared with the observed C^{13} nuclear hyperfine splittings, whilst theoretical calculations (Abstr. 15771 of 1960) indicate the reverse.

W.J.Orville-Thomas

6027

A SIMPLE APPROXIMATION TO THE EXCHANGE INTEGRAL OF QUANTUM CHEMISTRY.

T.Szondy.

Acta. phys. Hungar., Vol. 12, No. 1, 89-91 (1960). In German.

Integrals of the type $I = \int U(R, s)V(t)d\tau$ (r, s coordinates of the two electrons and t their separation) can be expressed in the form $\int_0^\infty C(t)\,V(t)dt$ by means of a function C(t), defined in a subspace T_i of variables $x_1, \ldots, x_n$, as

$$C(t_i) = \lim_{\Delta t_i \to 0} \frac{\int_{(T_i)} U \,.\, dx_1 \ldots dx_n}{\Delta t_i}$$

Approximations for the function C(t) give results in good agreement with the exact values in the example given of the Coulomb and exchange integrals between two hydrogen 1s eigenfunctions.

R.G.C.Arridge

6028

ELECTRONEGATIVITY EFFECTS OF HYBRIDIZED CARBON ATOMS.

M.G.Brown.

J. chem. Phys. (USA), Vol. 33, No. 6, 1881-2 (Dec., 1960).

An attempt is made to correlate observed bond lengths and electronegativity differences in various carbon—halogen bonds. The electronegativity is assumed to be a function of the hybridization state of the atom. It is noted that for C—H bonds Δx (the electronegativity difference) increases, and Δd (the bond length increase) decreases; and for C—Cl bonds Δx decreases whilst Δd increases. The conclusions however are only tentative since (1) the hybridized radii allow too much for hybridization effects in their derivation from C—C bonds; (2) the values of the electronegativities of the hybridized carbon atoms are very uncertain. T.E.Peacock

6029 DETERMINATION OF RELATIVE ELECTRONIC TRANSITION PROBABILITIES BY IMPACT METHODS.

F.H.Dorman and J.D.Morrison.
J. chem. Phys. (USA), Vol. 34, No. 2, 578-82 (Feb., 1961).

The possibility of obtaining relative electronic transition probabilities from ionization efficiency data is discussed. It is claimed that measurements of relative maximum ionization cross-section lack much theoretical significance. It is shown that the factors determining the detailed form of the ionization efficiency curves need to be considered, and that when this is done it should be possible to calculate relative transition probabilities from the experimental data. An illustration is given of such a calculation for several states of excited and ionized krypton and xenon.

6030 CHANGES IN THE ELECTRONIC TRANSITIONS OF AROMATIC HYDROCARBONS ON CHEMICAL SUBSTITUTION. I. PERTURBATION THEORY FOR SUBSTITUTED CYCLIC POLYENES. J.Petruska.

J. chem. Phys. (USA), Vol. 34, No. 4, 1111-20 (April, 1961).

General formulas are derived by first- and second-order perturbation theory for the changes in the transition moment, transition probability, and frequency of aromatic cyclic-polyene transitions produced by ideal chemical substitutions. The changes are described in terms of the interactions of three kinds of prototype electronic states; carbon-ring states, substituent states, and charge-transfer states. The interaction of the ring states with one another is regarded as an inductive effect of substitution; the interaction with the substituent and charge-transfer states, as a conjugative effect. Using the symmetry properties of the prototype states and assuming that the interactions are caused by a sum of perturbation operators for the individual of substituents, it is shown how the changes depend on the nature, the number, and the positions of the substituents on the ring. Formulas pertaining to the singlet—singlet pi-electronic transitions in benzene are given.

6031 CHANGES IN THE ELECTRONIC TRANSITIONS OF AROMATIC HYDROCARBONS ON CHEMICAL SUBSTITUTION. II. APPLICATION OF PERTURBATION THEORY TO SUBSTITUTED-BENZENE SPECTRA. J.Petruska.

J. chem. Phys. (USA), Vol. 34, No. 4, 1120-36 (April, 1961).

An analysis is made of the changes that occur in the 2600, 2050, and 1850 A transitions of benzene on chemical substitution. Formulas derived by first- and second-order perturbation theory, with coefficients evaluated by molecular orbital theory, are presented and applied to a large collection of intensity-change and frequency-shift data obtained from the literature. Most of these data pertain to the 2600 A transition. The first-order intensity formula derived for the 2600 A transition (taking the excited state to be $^1B_{2u}$) is found to hold quite well for substituents with monoshift (frequency shift on monosubstitution) less than 1500 cm^{-1}; the first- and second-order frequency-shift formula, for substituents with monoshift less than 2000 cm^{-1}. No attempt is made to analyse the intensity changes observed in the 2050 and 1850 A transitions as these changes are too small, relative to the initial intensity, to be reliably measured for weakly perturbing substituents from existing spectra. The frequency shifts, however, can be measured fairly reliably for these two transitions, and it is shown that the formulas derived on the basis of $^1B_{1u}$ and $^1E_{1u}$ excited states, respectively, hold for methyl substitution at least. Empirical values of the intensity and frequency perturbation parameters for the 2600 A transition are presented for over 30 substituents; values of the frequency perturbation parameters for the 2050 and 1850 A transitions for more than half of these, are also presented. The meaning of the parametric values is discussed in the light of theoretical expectations.

6032 INFLUENCE OF THE MOLECULAR ENVIRONMENT ON THE CARBONYL FREQUENCY. ELECTRONIC CALCULATION. S.Bratož and S.Besnainou.

J. chem. Phys. (USA), Vol. 34, No 4, 1142-8 (April, 1961).

The $K_{v_{C=O}}$ force constants of formaldehyde, acetaldehyde, acetone, glyoxal, p-benzoquinone, o-benzoquinone, and of chloroacetaldehyde are determined by Pariser—Parr—Pople's SCF-MO procedure. The theoretical expression for the force constant corresponding to this theory is given. The $K_{v_{C=O}}$ force constant is found to decrease in the order formaldehyde, chloroacetaldehyde, acetaldehyde, acetone; this is due to the corresponding decrease of the effective electronegativity of the carbonyl carbon atom. Th $K_{v_{C=O}}$ force constant decreases also in the series acetone, o-ben quinone, p-benzoquinone, and in the series acetaldehyde, glyoxal; this is due to conjugation effects. The force constants calculated by this theory agree satisfactorily with the experimental values.

6033 ON THE POSSIBILITY OF THE APPEARANCE OF FLUORESCENCE IN MOLECULES. Z.Simon.

Stud. Cercetari Fiz. (Roumania), Vol. 9, No. 4, 469-81 (1958).
In Roumanian.

The author attempts to give in this work a quantum mechanic method, which permits calculation of the frequency of an internal non-radiative transition in a molecule (consisting of the transformation of electronic excitation energy into energy of vibration This frequency determines the possibility of appearance of fluorescence. In this case a first order perturbation treatment is applied. The perturbation which produces the transition is given by the terms which are neglected in the Born—Oppenheimer appr mation. With the help of a metallic model for the functions of the electronic state and a harmonic approximation for the vibrational functions of the nuclei, the author attempts to provide a theoretic foundation for certain empirical rules, which have been shown to govern the possibility of appearance of fluorescence.

R.C.Seym

6034 ON THE NON-RADIATIVE TRANSITIONS OF β-NAPHTHYLAMINE. Z.Simon.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 317-28 (1959).
In Roumanian.

The experimental data about the fluorescence and phosphorescence of the aromatic hydrocarbons as well as their derivative in the gaseous state or in solution are obtained. Then the hypoth is made that the internal extinction of the fluorescence is due to the non-radiative transition between the singlet excited and singl ground states; this transition demands an activation energy, whe as the occurrence of fluorescence is conditioned by non-radiativ excited singlet—triplet transitions, which are almost independen temperature. The time constants of the non-radiative transition are calculated using certain theoretical hypotheses previously expounded on the model of β-naphthylamine. The temperature dependence and the order of magnitude of the calculated time con stants are verified by experiment. A.Ashr

6035 THREE-DIMENSIONAL FE-MO MODEL. I. ΔH OF DISSOCIATION OF HOMONUCLEAR DIATOMIC MOLECULES. S.L.Matlow.

J. chem. Phys. (USA), Vol. 34, No. 4, 1187-90 (April, 1961).

By means of a three dimensional FE-MO model, the ΔH's of dissociation for homonuclear diatomic molecules can be estima The atoms are represented by cubes, and the molecules by rect gular parallelepipeds. The parameters involved are the sizes o boxes and the effective mass of the electrons. The spectroscopi terms for the ground states of both the atoms and the molecules are obtained from the model.

6036 STUDIES IN MOLECULAR STRUCTURE. III. POPULATIONS ANALYSES FOR SELECTED FIRST-ROW DIATOMIC MOLECULES. S.Fraga and B.J.Ransil.

J. chem. Phys. (USA), Vol. 34, No. 3, 727-42 (March, 1961).

For Pt II, see Abstr. 17816 of 1960. Electronic population analyses for selected diatomic molecules of the first row of the periodic table are tabulated. The tentative value of population analyses in relation to accuracy of approximation is discussed briefly.

6037 CHOICE OF PARAMETERS FOR THE HÜCKEL π-ELECTRONIC STRUCTURE OF FURAN: TENTAT EXTENSION TO PYRROLE AND THIOPHENE.

F.L.Pilar and J.R.Morris, II.
J. chem. Phys. (USA), Vol. 34, No. 2, 389-92 (Feb., 1961).

A comparison of the experimental bond lengths of furan with empirical bond-length/bond-energy relations for carbon—oxygen bonds leads to the conclusion that the ratio of the carbon—oxyge resonance integral to the carbon—carbon resonance integral of furan is between about 0.1 to 0.3. Use of this value along with a Coulombic integral parameter based upon the ultraviolet absorption spectrum of furan leads to a Hückel molecular orbital pictu of the π-electronic structure of furan which is compatible with th nown chemical reactivity of the molecule. The same approach is sed to suggest resonance and Coulombic parameters for the Hückel olecular orbital treatment of pyrrole and thiophene. The treatment ields atom localization energies and para-localization energies onsistent with the relative chemistries of furan, pyrrole and iophene.

6038
THEORETICAL MOLECULAR TRANSITION PROBABILITIES. I. THE V—N TRANSITION IN H_2.

.Ehrenson and P.E.Phillipson.
. chem. Phys. (USA), Vol. 34, No. 4, 1224-31 (April, 1961).

Theoretical investigation of the oscillator strength of the V—N ransition in H_2 is carried out employing the alternative length, elocity, and acceleration operator methods in the calculations. By uccessive improvements in the approximate molecular wave-functions assumed for the two states, convergence of the results btained by the three methods toward a unique f value is demonstrated. The best wave-functions employed yield an f value of 0.27 for the V—N transition in H_2. Because in general the three methods weight ifferent spatial portions of the wave-functions in the dipole strength ntegrals, comparison of the alternative numerical f values is shown o provide some insight into the goodness, over-all and regional, of hese wave-functions. Agreement among the three values is also hown to be more sensitive test of the goodness of the wave-functions han are the usual energy criteria. All integrals necessary in these omputations are shown to be expressible in terms of $C_{\alpha\beta}{}^{\gamma\delta\epsilon}$ functions which are to be found in the literature. A systematic scheme or computing the oscillator strengths of any $\Sigma-\Sigma$ transition involving one and two quantum-number Slater orbitals in terms of these C functions is outlined.

6039
THE SPO (SPLIT p-ORBITAL) METHOD AND ITS APPLICATION TO ETHYLENE.

M.J.S.Dewar and N.L.Hojvat.
J. chem. Phys. (USA), Vol. 34, No. 4, 1232-6 (April, 1961).

Difficulties arise in the MO treatment of π-electron systems lue to electron correlation. Current methods allow, explicitly to some extent, for horizontal correlation (i.e., correlation of electron motions parallel to the carbon skeleton) but not for vertical correlation, (i.e., correlation of electron interchange between the two π lobes). A method for doing this, first suggested by Dewar and Wulfman is outlined and applied to ethylene with satisfactory results.

6040
ELECTRON SPIN RESONANCE STUDY OF p-PHENYLENE-DIAMINE POSITIVE ION.

M.T.Melchior and A.H.Maki.
J. chem. Phys. (USA), Vol. 34, No. 2, 471-6 (Feb., 1961).

The mono-positive radical ion of p-phenylene diamine was prepared by controlled potential electrolysis and studied by electron spin resonance. This ion was formed in acetonitrile solution with sodium perchlorate as supporting electrolyte and the controlled potential electrolysis was carried out in the microwave cavity of he e.s.r. spectrometer. The ion exhibits a complex hyperfine structure in dilute solution; the observed spectrum consists of bout 75 hyperfine components. Isotropic hyperfine coupling constants are assigned for the three types of interacting nuclei: the romatic ring protons, amine protons, and the nitrogen nuclei. The arge nitrogen hyperfine interaction observed is in marked contrast o Würster's Blue cation, for which this interaction is vanishingly mall. E.S.R. spectra of deuterated derivatives were obtained and mployed in making the assignment. The magnitude of the nitrogen yperfine interaction relative to that of the amine protons is shown o be consistent with the mechanism of a $\pi-\sigma$ electron exchange nteraction on the nitrogen atom. Electrochemical generation allows he study of the relatively unstable ion-radical, whereas other nethods of preparation have been less successful.

6041
ANOMALOUS RELAXATION OF HYPERFINE COMPONENTS IN ELECTRON SPIN RESONANCE. II.

.W.H.Schreurs and G.K.Fraenkel.
. chem. Phys. (USA), Vol. 34, No. 3, 756-68 (March, 1961).

For previous part, see Abstr. 15756 of 1960. A detailed study as made of the linewidth and peak height of each of the five components in the electron spin resonance spectrum of the p-benzosemiquinone ion as a function of microwave power at X-band frequencies. udies were also made of the spectrum of the peroxylamine disulphonate ion as a function of power. A 20% variation in the linewidths from one hyperfine component to another was found in the -benzosemiquinone ion spectrum, and a 13% variation in the saturation parameters (T_1). The average value for the linewidth parameter at low power for the p-benzosemiquinone ion was found to be $(1/T_2) = 1.11 \times 10^6\ \mathrm{sec}^{-1}$, and the reciprocal of the average value of the saturation parameter was found to be about $(1/T_1) = 0.74 \times \times 10^6\ \mathrm{sec}^{-1}$. No variation in linewidths or saturation parameters among the three hyperfine components in the peroxylamine disulphonate ion spectrum was found, and the results were $T_2 = 2.5 \times \times 10^{-7}$ sec, and $T_1 = 3.3 \times 10^{-7}$ sec. The variation in the linewidth of the p-benzosemiquinone ion can be accurately represented by a quadratic equation in m_J, the field-direction component of the total nuclear spin angular momentum, and the form of this equation is in excellent agreement with the linewidth predicted for a relaxation mechanism arising from an anisotropic intramolecular dipolar interaction between the unpaired electron and the four protons in the molecule, as well as a rotational relaxation of the anisotropic g tensor. Good quantitative agreement between theory and experiment is obtained for the coefficient of m_J^2 in the equation for $(1/T_2)$ if the rotational correlation time is taken to be $\tau_C = 7 \times 10^{-11}$ sec, a value which is consistent with the molecular dimensions. The dependence of the saturation parameters on m_J is also in qualitative agreement with the theory, but quantitative discrepancies are found which have not been explained.

6042
ANISOTROPIC HYPERFINE INTERACTIONS IN THE E.S.R. SPECTRA OF ALKYL RADICALS.

E.L.Cochran, F.J.Adrian and V.A.Bowers.
J. chem. Phys. (USA), Vol. 34, No. 4, 1161-75 (April, 1961).

The effect was studied of anisotropic hyperfine interactions on the electron spin resonance spectra of alkyl radicals trapped in polycrystalline matrices. The anisotropy broadens some of all of the h.f.s. components, thus complicating the spectra. In alkyl radicals one has both isotropic and anisotropic h.f.s. interactions with the α protons, but only an isotropic interaction with the β protons. Computed and experimental line shapes for the ethyl and propyl radicals are in qualitative agreement, provided that the h.f.s. interaction is averaged over the various equilibrium orientations of the $-CH_2\cdot$ group. This implies a rapid reorientation of the $-CH_2\cdot$ group. It is noteworthy that when the two α protons are antiparallel the hyperfine anisotropy cancels and sharp intense h.f.s. components result, while parallel orientations of the α protons give broad weak h.f.s. lines. In particular, if the broad weak lines associated with the α proton h.f.s. interactions are overlooked, the propyl radical spectrum appears to be a triplet, implying h.f.s. interactions with the β protons only. In radicals where there is an odd number of α hydrogens (e.g. R'—CH—R) there is no possibility of cancellation, and all the lines will be broad and weak. Attempts to observe radicals of this type were unsuccessful, most likely for this reason.

6043
NOTE ON THE CALCULATION OF SATURATION EFFECTS IN MAGNETIC RESONANCE.

M.J.Stephen.
J. chem. Phys (USA), Vol. 34, No. 2, 484-9 (Feb., 1961).

A simple method using diagrams is described for calculating saturation parameters in spin systems. Results are derived for the multiresonance case. The lattice is regarded as inducing transitions among the various spin levels and the transition probabilities are assumed known. The method is particularly useful in complicated spin systems as are found in organic free radicals. For a free radical in solution with one odd electron and N equivalent nuclei under conditions where the intramolecular electron nuclear dipole-dipole interaction and g factor anisotropy contribute to the relaxation, the dependence of the saturation parameters of the electron resonance spectrum on the nuclear quantum number m_J is given by an expression of the form $Am_J^2 + Bm_J + C$. Such behaviour has been found experimentally.

6044
QUADRUPOLE RELAXATION EFFECTS IN NUCLEAR MAGNETIC DOUBLE RESONANCE.

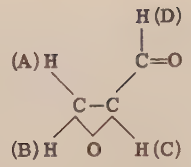
J.D.Baldeschwieler.
J. chem. Phys. (USA), Vol. 34, No. 3, 718-23 (March, 1961).

The effects of quadrupole relaxation on the relative linewidths of the double resonance spectrum of a molecule in the liquid state are described. Only the special case is considered for which the broadening of individual components by quadrupole relaxation is not great enough to lead to complete collapse of a spin-multiplet. It is assumed that line separation is large compared to linewidth. The calculations are illustrated for the ammonia molecule.

6045
N.M.R. SPECTRA OF GLYCIDALDEHYDE.

C.A.Reilly and J.D.Swalen.
J. chem. Phys. (USA), Vol. 34, No. 3, 980-91 (March, 1961).

The spectra were measured at 40 and 60 Mc/s.



These complicated spectra of four interacting protons were analysed by two methods: the ABKY approximation and the iterated ABCD solution. The various mathematical techniques developed should prove useful in the analyses of other complicated spin resonance spectra. The following spin–spin coupling constants, J_{ij} in cycles per second and chemical shifts, δ_i in parts per million (relative to tetramethylsilane) were found:

	J_{AB}	J_{AC}	J_{BC}	J_{AD}	J_{BD}	J_{CD}
40 Mc/s	5.54	2.04	4.90	−0.03	−0.32	6.36
60 Mc/s	5.54	2.09	4.87	+0.03	−0.31	6.24

	δ_A	δ_B	δ_C	δ_D
40 Mc/s	3.096	3.158	3.356	8.922
60 Mc/s	3.098	3.166	3.356	8.922

The first three coupling constants are very close in magnitude to those obtained in other epoxides (in most cases to within 0.5 c/s). The magnitude of the coupling constant between the aldehyde proton (D) and the adjacent proton (C) indicates that the D proton of the aldehyde group is probably on a time average, mainly in a plane perpendicular to the epoxide ring. The proton (D) could be either cis or trans to proton (C), but from a consideration of internal rotation interactions, it is probably in the trans configuration. The J_{AC} and J_{BC} coupling constants are consistent with an "eclipsed-ethanelike" model rather than with an "ethylenelike" one. The coupling constants across the molecule, J_{AD} and J_{BD}, are an order of magnitude smaller than the other constants. This is in agreement with the approximate attenuation factor of 1/10 for spin–spin coupling through a single bond.

6046 PROTON MAGNETIC RESONANCES OF SOME BORAZOLE DERIVATIVES.

K.Ito, H.Watanabe and M.Kubo.

J. chem. Phys. (USA), Vol. 34, No. 3, 1043–9 (March, 1961).

The proton magnetic resonance spectra of ten borazole derivatives were recorded and assignments carried out. The chemical shifts of BH and NH protons are close to each other, the values being nearly equal to the sum of the contribution of a diamagnetic ring current and the chemical shift of C=CH–C protons. The signals of NH and BH protons showed the partial collapse of multiplet structures due to quadrupole relaxation. BC_2H_5 protons gave a single sharp line instead of showing both methyl and methylene signals each split by I–I coupling. An explanation is given in terms of electronegativity considerations.

6047 PROTON MAGNETIC RESONANCE SPECTRA OF COMPOUNDS OF THE TYPE $X(C_2H_5)_n$. RELATIVE SIGNS OF THE X–H SPIN COUPLING CONSTANTS.

P.T.Narasimhan and M.T.Rogers.

J. chem. Phys. (USA), Vol. 34, No. 3, 1049–55 (March, 1961).

The high-resolution proton magnetic resonance spectra of phosphorus triethyl, tin tetraethyl, and lead tetraethyl were studied at both 40 Mc/s and 60 Mc/s. The various spin–spin coupling constants (J) and the proton internal chemical shift (δ) values for these molecules are obtained by an analysis of the spectra as A_3B_2 and A_3B_2X systems. (A denotes CH_3 group protons, B the CH_2 group protons, and X is a nucleus other than the proton with spin $\frac{1}{2}$ such as P^{31}, Sn^{117}, Sn^{119}, or Pb^{207}.) In phosphorus triethyl it is found that J_{AX} and J_{BX} have opposite signs. The proton magnetic resonance spectrum of tin tetraethyl is a complex A_3B_2 type spectrum even at 60 Mc/s with "satellite" lines from naturally present Sn^{117} $(C_2H_5)_4$ (7.67%) and Sn^{119} $(C_2H_5)_4$ (8.68%) in the sample. Analysis of the satellite spectrum as an A_3B_2 type shows that J_{AX} and J_{BX} have opposite signs (here X = Sn^{117} or Sn^{119}). The proton resonance spectrum of lead tetraethyl is reinvestigated and it is found that the satellite lines due to Pb^{207} $(C_2H_5)_4$ do not show any asymmetry, in contrast with earlier observations of Baker. Probable causes for Baker's results are given and it is shown theoretically and experimentally that such an asymmetry does not truly exist. The coupli constants J_{AX} and J_{BX} are found to have opposite signs in lead tetraethyl also.

6048 N.M.R. SPECTRA OF PROPYL DERIVATIVES.

J.R.Cavanaugh and B.P.Dailey.

J. chem. Phys. (USA), Vol. 34, No. 4, 1094–8 (April, 1961).

A perturbation treatment, carried to third order in the energi and first order in the intensities of the analysis of the propyl grou spectra, is presented. Accurate values are given for the coupling constants and the chemical shifts of the common propyl derivative both for the pure compound and as extrapolated to infinite dilution in carbon tetrachloride.

6049 PROTON CHEMICAL SHIFTS FOR THE ALKYL DERIVATIVES.

J.R.Cavanaugh and B.P.Dailey.

J. chem. Phys. (USA), Vol. 34, No. 4, 1099–1107 (April, 1961).

The chemical shifts of a series of methyl, ethyl, propyl, and isopropyl derivatives were studied in an effort to determine the distance and angular dependence of any contribution to the chemic shift arising from magnetically anisotropic substituent groups. It was found that electron withdrawal effects play a dominant role in determining the chemical shifts for methyl derivatives. The nearly exactly linear relation of the methyl shifts to electronegativit for the methyl halides seems to rule out any large influence due t magnetic anisotropy. The ethyl shifts were found to be determine by electron withdrawal effects plus a factor which acted equally at the α and β positions. It was found that this factor arises from the carbon–carbon bond. By assigning a chemical shift due to the presence of the C–C bond, which is dependent in size on the subst tuent attached to the α carbon, the apparently anomalous frequenci observed for the alkyl derivatives can be accounted for. A possib explanation for the C–C bond shift may be regular changes in the paramagnetic term in the Ramsey equation due to changes in the excitation energy denominator when a C–C bond replaces a C–H b

6050 PRESSURE DISSOCIATION.

M.S.Vardya.

Astrophys. J. (USA), Vol. 132, No. 3, 905 (Nov., 1960).

At high gas densities (~10^{-2} gm cm^{-3}) and temperatures (~10^{4} the number of undissociated molecules predicted is decreased con siderably if pressure dissociation, as well as thermal dissociatio is considered. The effect on hydrogen molecules is discussed.

G.I.W.Llewel

6051 ALKALI–IRON GROUP–HALOGEN COMPLEXES. DISSOCIATION ENERGIES OF $KClFeCl_2$ AND $CsClFeCl_2$.

V.S.Rao and P.Kusch.

J. chem. Phys. (USA), Vol. 34, No. 3, 832–6 (March, 1961).

A number of complexes between the alkali halides and the divalent halides of the iron group metals were studied. They are al characterized by a very large rotational magnetic moment of the order of 50 nuclear magnetons for the rotational state of most pro bable J. The dissociation energies at a temperature of about 1020° K of the two complexes, $KClFeCl_2$ and $CsClFeCl_2$, were fou to be 34.7 ± 1.0 and 24.7 ± 1.0 kcal M^{-1}, respectively. The data from which these results were found were obtained by measuring the relative concentrations of the alkali halide and the complex as function of temperature while the partial pressure of $FeCl_2$ remained essentially constant. The large difference in the magneti moments of the two detectable molecular species allows the deter mination of the relative concentration with considerable accuracy.

6052 THE DISSOCIATION ENERGIES OF THE H_2, HD, AND D_2 MOLECULES.

G.Herzberg and A.Monfils.

J. molecular Spectrosc. (USA), Vol. 5, No. 6, 482–98 (Dec., 1960).

The far ultraviolet absorption edges were studied under high resolution and the different limits corresponding to absorption fro different lower state rotational levels were observed. The sharp of the limits for low, as compared with those for high J values, sh that the upper electronic state (which in all probability is the C $^1\Pi_u$ state) has no potential maximum which might have falsified the values of the dissociation limit. From the precisely measured edges new values for the dissociation energies are determined: $D_0^0(H_2) = 36\,113.0 \pm 0.3\ cm^{-1}$; $D_0^0(HD) = 36\,399._9 \pm 1._0\ cm^{-1}$; $D_0^0(D_2) = 36\,743.6 \pm 0.5\ cm^{-1}$. If B′ $^1\Sigma_u$ rather than C $^1\Pi_u$ is the upper state of the continuum these values would have to be raised 0.6 cm^{-1}. The zero-point energies of the three molecules are dete mined from the most recent data in the literature including the correction term Y_{00} due to the finer interaction of vibration and rotation. The addition of these zero-point energies to the D_0^0 give independent D_e values for the three molecules. A slight difference between $D_e(H_2)$ and $D_e(D_2)$ is found which is ascribed to an elec-ronic isotope effect caused by a difference in the effect of nuclear motion in the molecule from that in the separated atoms. The magni-ude of the effect is in agreement with predictions by Van Vleck. After correction for this effect one obtains the dissociation energy for infinite mass $D_e(^{\infty}H_2) = 38\,287.0 \pm 0.8$ cm^{-1}, a value that agrees extremely well with Kolos and Roothaan's recent theoretical value Abstr. 17811 of 1960).

6053 THEORETICAL DISCUSSION OF THE PHOTODISSOCIATION OF ANILINE MOLECULES. Z.Simon.

Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 2, 291-305 (1959). In Roumanian.

In the usual rate equation $\alpha = A\exp(-E/RT_V)$ where T_V is the vibration temperature, the factor A is calculated for the photodissociation of excited aniline molecules in u.v. radiation (2500 - 2900 A). Simple Huckel molecular orbitals were used to describe the electronic state wave-functions. The influence of the $-NH_2$ group is considered as a perturbation dependent on the C-N internuclear distance. For the vibrational wave-function for the C-N bond, a harmonic oscillator approximation was used to describe the excited state and the particle-in-a-box approximation used to describe the vibrational states in the ground state. The agreement between theoretical and experimental values of A is good. T.E.Peacock

6054 STRENGTH OF THE N—N BOND IN TETRAFLUOROHYDRAZINE. C.B.Colburn and F.A.Johnson.

J. chem. Phys. (USA), Vol. 33, No. 6, 1869-70 (Dec., 1960).

The dissociation of

$$N_2F_4 \rightleftharpoons 2NF_2 \quad (1)$$

was investigated by two methods (a) measurement of pressure variation with temperature at constant volume, and (b) the temperature dependence of the u.v. absorption band at 260 mμ. It is found that $\Delta H = +19.2$ kcal and $\Delta S = 38.6$ e.u. for the reaction. From these values it is predicted that under normal conditions of measurement of mass spectrometer ionization sections, N_2F_4 will be completely dissociated into NF_2. Mass spectrometer measurements support this theory. T.E.Peacock

6055 SPIN DENSITIES IN SEVERAL ODD ALTERNANT RADICALS. H.H.Dearman and H.M.McConnell.

J. chem. Phys. (USA), Vol. 33, No. 6, 1877-8 (Dec., 1960).

Simple valence bond theory (omitting all ionic and long bond structures) was used to calculate spin densities in the benzyl, α-methylnaphthenyl, p-methylnaphthenyl and trivinylmethyl radicals. T.E.Peacock

6056 BEHAVIOR OF THE FREE RADICALS TRAPPED IN GAMMA-IRRADIATED COMPOUNDS WHICH CONTAIN HYDROGEN BONDS.

Z.Kuri, Y.Fujiwara, H.Ueda and S.Shida.

J. chem. Phys. (USA), Vol. 33, No. 6, 1884-5 (Dec., 1960).

The e.s.r. spectra of free radicals formed in γ-irradiated polyvinyl alcohol were found not to change on exposure to air, Cl_2, I_2, NO, SO_2 or H_2S. Radicals formed by irradiation of a number of sugars were found to be similarly "stable". It is suggested that the radicals are protected from interaction with the gases by a network of intermolecular hydrogen bonds which prevents penetration by the latter. R.C.Seymour

6057 THE BEHAVIOUR OF HYDRAZOIC ACID IN A SHOCK WAVE; NEW DATA ON THE $^3\Pi-^3\Sigma$ SYSTEM OF NH.

H.Guenebaut, G.Pannetier and P.Goudmand.

C.R. Acad. Sci. (France), Vol. 251, No. 11, 1166-8 (Sept. 12, 1960). In French.

The passage of a shock wave through NH_3 is accompanied by decomposition of the molecule and very intense luminescence. NH, OH bands and a continuum (possibly due to NH_2) are observed in the luminescence spectrum. The $\Delta v = 0$ sequence of the NH $^3\Pi-^3\Sigma$ transition is particularly prominent and a new (3,3) band is observed at 3402 A. Its positive identification is confirmed by the wavelength shift of the isotopic ND band. R.W.Nicholls

6058 INTRAMOLECULAR AND INTERMOLECULAR ENERGY CONVERSION INVOLVING CHANGE OF MULTIPLICITY.

G.Porter and M.R.Wright.

Disc. Faraday Soc. (GB), No. 27, 18-27 (1959).

"Energy transfer" Discussion, Nottingham, 1959 (see Abstr. 4920 of 1961). Radiationless transitions between states of different multiplicity are considered with special reference to conversion between triplet and singlet energy levels. Rates of this conversion were measured for naphthalene and anthracene and rate constants are given for the first-order intramolecular process, the second-order process involving two triplet molecules and also of quenching by other species, particularly paramagnetic ions. It is established that the first-order rate in strongly viscosity dependent and this is attributed to a structural difference between the two states. Conversion from the triplet state is induced by paramagnetic molecules and ions but the quenching rate constant shows no correlation with magnetic susceptibility. A general theory of "paramagnetic quenching" is proposed in which the function of the quenching molecule is one of overall spin conservation.

6059 OUTER AND INNER MECHANISM OF REACTIONS OF EXCITED MOLECULES. A.Weller.

Disc. Faraday Soc. (GB), No. 27, 18-33 (1959).

"Energy transfer" Discussion, Nottingham, 1959 (see Abstr. 4920 of 1961). The distinction between outer and inner mechanism (introduced by Förster, 1951) is outlined in connection with the quenching of fluorescence. The same distinction is applied to acid—base reactions of excited molecules, where the inner mechanism is known in principle. The rate constants of these reactions exhibit a rough parallelism with the corresponding equilibrium constants. Upper limiting values of the reaction rate constants are calculated using the equilibrium constants, the diffusion coefficients of the reactants, and steric factors (closely related to the statistical factors of the respective equilibria). Good agreement with the experimental rate constants proves that the "inner" proton transfer equilibrium is established in a time which is much shorter than the mean lifetime of the excited molecules. Exceptions occur with proton transfer reactions between nitrogen atoms. The influence of the environment on the inner mechanism is discussed.

6060 ENERGY TRANSFER IN SYSTEMS OF CONNECTED ORGANIC MOLECULES.

A.Terenin, E.Putzeiko and I.Akimov.

Disc. Faraday Soc. (GB), No. 27, 83-93 (1959).

"Energy transfer" Discussion, Nottingham, 1959 (see Abstr. 4920 of 1961). Transport of charges, liberated by light in crystalline pigments (chlorophyll, methylchlorophyllide, haemin, the phthalocyanines) has been studied and their sign determined with two condenser methods. The positive carriers of photoconduction imply an oxidation-reduction intermolecular exchange of electron at the ground levels. Sensitization of the photoelectric effect in inorganic semiconductors by adsorbed pigments has been studied and interpreted as energy transfer. A light-induced proton exchange in layers of amphoteric acridine derivatives has been observed in fluorescence at low temperature, as an extension of a previous work on acridine in a matrix of organic acids in vacuo.

6061 MOLECULAR ASSOCIATION IN ALKALI HALIDE VAPORS. S.Datz, W.T.Smith, Jr., and E.H.Taylor.

J. chem. Phys. (USA), Vol. 34, No. 2, 558-64 (Feb., 1961).

Molecular association equilibria in alkali halide vapours were studied by measuring the temperature dependence of the molecular weights of gaseous NaCl, NaBr, NaI, KCl, KI, RbCl, and CsCl. The molecular weights were determined by measurement of the absolute pressure exerted by a known weight of completely vaporized salt contained in an isothermal fused silica bulb of known volume. The pressure sensing element was a fused silica manometer containing molten gold. The apparatus was used in the temperature range of 1175° to 1430°K and pressures of from 10 to 40 mm were measured with a precision of ±0.05 mm. The temperature dependence of the equilibrium constants for the reaction $(MX)_2 \rightleftharpoons 2MX$ yielded dissociation energies (evaluated at 1300°K) ranging from 48.0 kcal mole^{-1} for NaCl to 34.7 for CsCl. The entropies of dissociation were found to fall within a small range, varying from 28.3 e.u. for NaCl to 25.0 for KI, and a statistical calculation of the entropy changes based on an ionic model was found to agree well with the experimental values. It is shown that these systems may be adequately described with an electrostatic model, although closer attention should be paid to the nature of polarization interactions.

6062 CONFIGURATIONAL CHANGES OF POLYPEPTIDE MOLECULES IN THE HELIX-COIL TRANSITION REGION. I. K.Nagai.

J. Phys. Soc. Japan, Vol. 15, No. 3, 407-16 (March, 1960).

Formal expressions are derived for the mean square of the end-to-end distance and the electric moment of polypeptide molecules in the helix-coil transition region. It is assumed that each amino acid residue of a polypeptide molecule in the transition region is involved either in a helical section or in a randomly coiled section. A partition function of a polypeptide molecule is constructed by means of the matrix method. First, the partition function is used in obtaining the average of some scalar quantities, e.g., the mean fraction of residues involved in helical sections. Next, the average of a product of matrices is obtained, which is used in calculating the mean square of the end-to-end distance and the electric moment. Expressions for the α-helix are also derived. An improved partition function including various effects, e.g., the end effect, is given in an appendix.

6063 DIMENSIONAL CHANGE OF POLYPEPTIDE MOLECULES IN THE HELIX-COIL TRANSITION REGION. II.

K.Nagai.

J. chem. Phys. (USA), Vol. 34, No. 3, 887-904 (March, 1961).

The mean-square end-to-end distance $\langle R^2 \rangle$ and radius of gyration $\langle S^2 \rangle$ are calculated for polypeptide molecules in the helix-coil transition region. The helical content, the sequence length distributions of helical and randomly coiled sections, etc., are also calculated for illustration. The statistical mechanical model on which the present calculation is based, is essentially equal to the second models in Gibbs—DiMarzio's and Zimm—Bragg's theories, respectively, though formulation is made on a more general model for the two purposes, i.e., for some convenience in calculating various quantities and for an examination of the degree of approximation of the above model. As a result, this model is found to be very satisfactory in spite of its simplicity. In order to calculate chain dimensions, two configurational models are examined. The one (model I), is somewhat rigorous, account being taken of the effects of bond lengths, bond angles, and hindered rotations. Two kinds of residues, i.e., those involved in helical sections, and those in randomly coil sections, are distinguished by assigning different internal rotation potentials. The other (model II), is more approximate but more tractable. It can be obtained by replacing a helical section by a r with an appropriate length and a randomly coiled section by an appropriate random flight chain. Numerical computations show th the two models give very close results for the infinitely long chain in t region where essential dimensional change occurs. By using model II, the effects of statistical mechanical parameters on $\langle R^2 \rangle$ are examined in detail. As a result, for example, it it shown that the larger the mean number of residues involved in a helical secti becomes, the larger $\langle R^2 \rangle$ becomes, even if the helical content remains unchanged. For large N (e.g. $N > 300$), as chain configura tions go from randomly coiled to rodlike, $\langle R^2 \rangle$ and $\langle S^2 \rangle$ first decrease, pass through a minimum, and then increase until they rea the values for the perfect α helix. The appearance of this minim is due to the considerably extended local configuration of randoml coiled residues. Namely, the appearance of a short helical secti turns the extended configuration to the folded one of the α helix a hence the polymer chain shrinks.

6064 ANALYSIS OF REACTIVE SCATTERING IN CROSSED MOLECULAR BEAMS. D.R.Herschbach.

J. chem. Phys. (USA), Vol. 33, No. 6, 1870-1 (Dec., 1960).

An analysis of the experimental data of Greene, Roberts and Ross (Abstr. 6409 of 1960) for the K + HBr → H + KBr reaction is carried out, and the effects are outlined that must be taken into account in the interpretation of such data. W.J.Orville-Thom

SOLID-STATE PHYSICS

6065 THE STRUCTURE OF NON-DESTRUCTIVE TESTING.

K.W.Andrews.

Brit. J. appl. Phys. Vol. 12, No. 4, 127-33 (April, 1961).

"Non-Destructive Testing Conference", London, May, 1960 (see Abstr. 5132 of 1961). The physical basis of all non-destructive testing is emphasized. It is suggested that the "structure" (in a general sense) of non-destructive testing is based on two principal forms of energy, viz. the spectrum of electromagnetic radiations and fields and the spectrum of particle movements or vibrations in solids. The two are involved together or separately and are interpretable in terms of the structure (in a more physical sense) of the material, i.e. the electrons, atoms, molecules, crystal structure, etc. A unified scheme of relationships is suggested. Reference is made to a fundamental unity of the equilibrium physical properties of a perfect crystal so that physical methods of examination are similarly inter-related. The "real" materials of industry, and in particular metals, can be regarded as derived from perfect single crystals by the introduction of increasingly serious forms of lattice "imperfection" or irregularity such as solid solution strains, vacancies, domains, dislocations, etc., leading to the eventual appearance of grain boundaries, poly-phase structure, segragation, etc. The way in which various physical properties are used to interpret materials in those terms is indicated.

CRYSTALLOGRAPHY CONFERENCE, CAMBRIDGE, 1960.
See Abstr. 6488

6066 CRYSTAL FIELD SPLITTING AND COVALENT BONDING IN Fe++ SILICATE GARNETS.

P.Bloomfield, A.W.Lawson and C.Rey.

J. chem. Phys. (USA), Vol. 34, No. 3, 749-56 (March, 1961).

A point-ion model and Slater free-ion wave-functions are used to calculate the crystal field splitting of the Fe^{++} ion ^5D ground term in $Fe_3Al_2(SiO_4)_3$ garnet for various assumed charge distributions within the $(SiO_4)^{4-}$ ion. The best fit with Clark's experimental data on absorption spectra is obtained with about 50% covalent bonding between Si and O, and with an effective nuclear charge for the Fe^{++} ion about 10% less than that given by Slater's rules. This estimate of the degree of covalency is consistent with that given by Pauling. The calculated pressure dependence of the optical absorption is in satisfactory agreement with the experiments of Balchan and Drickamer.

6067 CALCULATION OF THE VAPOUR PRESSURE RATI OF Ne, A, Kr, AND Xe ISOTOPES IN THE SOLID STATE.

G.Casanova, R.Fieschi and N.Terzi.

Nuovo Cimento (Italy), Vol. 18, No. 5, 837-48 (Dec. 1, 1960).

In order to discuss the validity of the anharmonic Einstein model developed by Henkel (1955), the vapour pressure ratio of neon isotopes is recalculated, following Johns's method, by mak use of a Lennard-Jones (6-12) potential and of different couples parameters ϵ and σ. Results are compared with the recent expe mental data by Roth and Bigeleisen. The dependence of ln p_m/p from temperature is found to be scarcely sensitive to the choice molecular parameters and is in good agreement with experiment results. As to the absolute value of ln p_m/p_M at any given temp rature one does not find as good an agreement as claimed by Jo It is shown how the uncertainty in the determination of molecula parameters cannot explain the whole disagreement between expe ments and theory. Calculations for argon are carried on in the s scheme. Results are lower than preliminary experimental resu by Boato and Scoles. A brief discussion is given to suggest why difference in vapour pressure between two separated isotopes co be slightly different from the same quantity deduced by measuri the fractionation factor of an isotopic mixture. A possible influe of the isotopic composition of an isotopic solid mixture on the fr tionation factor is also pointed out. Finally the ln p_m/p_M for kr ton and xenon is calculated by means of the quantum theorem of corresponding states.

LATTICE MECHANICS

6068 THE THERMODYNAMICS OF IDEAL CRYSTALS.

S.K.Savvinykh.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6., No. 3, 400-11 (19
In Russian.

By writing the dynamical matrix of lattice dynamics as a sc matrix plus a "small" correcting matrix, it is shown that the thermodynamics of an ideal crystal can be expressed as a leadin term of the Einstein type (coming from the scalar matrix) together with "correction" terms involving the even moments of frequency distribution. The expressions are valid at all tempera tures but the "corrections" become bigger than the leading term temperatures below about $\Theta/10$. The theory is applied to solid argon using nearest-neighbour Lennard-Jones interactions. In common with other theories based on a harmonic Hamiltonian depending parametrically on volume there is disagreement with experiment above about 40°K, confirming the importance of anharmonicity in this region. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 20-33 (1958)]. R.O.Davies

CHARACTERISTICS OF Ni^{61*} FOR OBSERVATION OF THE MÖSSBAUER EFFECT IN A NICKEL LATTICE. See Abstr. 5830

CAPTURE OF SLOW NEUTRONS BY NUCLEI BOUND IN CRYSTALS: NEUTRON ANALOGUE OF MÖSSBAUER EFFECT. See Abstr. 5927

6069 ON THE VIBRATION SPECTRUM OF A DISORDERED LINEAR LATTICE. I. J.Mahanty.
Nuovo Cimento (Italy), Vol. 19, No. 1, 46-52 (Jan. 1, 1961).

The average eigenfrequency equation of a disordered two-component linear chain is derived by a direct algebraic method. It is shown that the moments of the frequency spectrum can be evaluated from this equation.

6070 PHONON DRAG IN LEAD.
A.V.Gold and W.B.Pearson.
Canad. J. Phys., Vol. 39, No. 3, 445-52 (March, 1961).

Measurements wer made on the thermoelectric power of dilute alloys of lead with the solutes Cd, In, Sn, Tl, and Bi in order to test a plausible hypothesis that much of the thermoelectric behaviour of pure lead at low temperatures can be ascribed to phonon drag. The results are qualitatively consistent with the phonon-drag picture only if it is assumed that the scattering of phonons by these impurities depends more critically on the valence difference between solvent and solute than on the mass difference.

6071 SELECTION RULE FOR THE INTERACTION OF MICROWAVE ULTRASONICS WITH SPINS.
N.S.Shiren and E.B.Tucker.
Phys. Rev. Letters (USA), Vol. 6, No: 3, 105-6 (Feb. 1, 1961).

The quadrupole selection rules derived by Mattuck and Strandberg (Abstr. 529 of 1960), for spin—phonon transitions for non S-state ions of the iron group, have been confirmed experimentally for one non S-state ion, Cr^{3+} in Al_2O_3, and for two S-state ions, Mn^{2+} and Fe^{3+} in MgO. In the experiments, 9 kMc/s longitudinal phonons and a microwave source were compared as producers of saturation of the spin resonance as the angle between the d.c. magnetic field and the sound wave was varied. Specimen results are given. See also two following abstracts. L.Mackinnon

6072 PHONON—PHOTON DOUBLE-QUANTUM TRANSITIONS AS A DETECTOR OF MICROWAVE ULTRASONICS.
N.S.Shiren.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 168-70 (Feb. 15, 1961).

The simultaneous absorption of a microwave photon and a kMc/s ultrasonic phonon was observed on the spin systems of Ni^{2+} and Fe^{2+} in MgO at 2° K. It is suggested that this provides a useful method of detecting kMc/s ultrasonic pulses; the microwaves are fed continuously to the system and are seen to be absorbed on the arrival of an ultrasonic pulse. Some experimental results are shown; so far, the method is less sensitive than piezoelectric detection, but improvements may be possible. L.Mackinnon

6073 ATTENUATION OF LONGITUDINAL ULTRASONIC VIBRATIONS BY SPIN—PHONON COUPLING IN RUBY.
E.B.Tucker.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 183-5 (Feb. 15, 1961).

A study was made of the attenuation of 9.1 kMc/s longitudinal ultrasonic waves in pink ruby. Experimental data are given of the ultrasonic transition probability as a function of the angle between the magnetic field and sound wave for various transitions, and some agreement with theory is found. Pulse techniques have enabled an approximate value of the attenuation per cm of path to be obtained, and from this the magnetoelastic coupling constant and the spin—lattice relaxation time are deduced. L.Mackinnon

---

Thermal Properties

6074 DETERMINATION OF THE ENTHALPY AND THE SPECIFIC HEAT OF BERYLLIUM AT 600 -2200°K.
P.B.Kantor, R.M.Krasovitskaya and A.N.Kisel'.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 835-7 (Dec., 1960). In Russian.

The enthalpy and the specific heat of pure beryllium were determined at 600-2200°K (solid and liquid phases), as well as the melting point and the latent heat of fusion. A.Tybulewicz

6075 ANALYSIS OF SPECIFIC HEAT DATA FOR ZINC. RESOLUTION OF THE CALORIMETRIC AND ELASTIC Θ_0 DISCREPANCY. C.W.Garland and J.Silverman.
J. chem. Phys. (USA), Vol. 34, No. 3, 781-2 (March, 1961).

The low-temperature heat capacity of zinc (in the normal state) is expressed by $C_V = \gamma T + \alpha T^3 + \beta T^5$ over the range from 0.15° K to about 8° K. The new parameters obtained are: $\gamma = 1.56 \times 10^{-4}$ cal/deg² mole, $\alpha = 1.39 \times 10^{-5}$ cal/deg⁴ mole, and $\beta = 2.44 \times 10^{-7}$ cal/deg⁶ mole. The calorimetric Debye temperature, $\Theta_0{}^C$, is found to be 322° K which is in reasonable agreement with the elastic value, $\Theta_0{}^E$, of 328° K. The apparent disagreement between $\Theta_0{}^C$ and $\Theta_0{}^E$ values cited in the literature arises from the difficulty in analysing the calorimetric data for a very anisotropic metal.

6076 A REVISION OF KELLERMANN'S CALCULATIONS OF THE SPECIFIC HEATS OF SODIUM CHLORIDE.
B.Dayal and B.B.Tripathi.
Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 303-4 (Feb., 1961).

In the well-known work on the lattice vibrations and the specific heats of sodium chloride, Kellermann (Abstr. 1978 of 1940; 1316 of 1941) has not assigned a correct statistical weight to several frequencies and has, further, omitted one point of the Brillouin zone. His results were, therefore, revised to take these factors into account.

6077 THERMAL CONDUCTIVITY OF SEMICONDUCTORS.
J.Appel.
Progress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961) p. 141-87.

Onsager's phenomenological theory of thermal conductivity as an irreversible transport process is generalized for anisotropic crystals. The eigenvalues of the stationary states of the electrons and lattice particles are formulated in adiabatic approximation, neglecting interactions. Thermal conduction in dielectrics is considered allowing for phonon interactions, and applied to the unbounded perfect crystal and a crystal with imperfections, in which additional scattering processes occur. The thermal conductivity is separated into the electronic conductivity and the phonon conductivity, and the former is discussed for extrinsic and intrinsic semiconductors. The scattering of phonons by electrons and superposition effects are treated. The influence of a magnetic field, other transport processes of radiation and excitons, and the relation to thermoelectric cooling are briefly considered. 96 refs. J.B.Birks

6078 THE EFFECT OF HYDROSTATIC PRESSURE ON THE THERMAL CONDUCTIVITY OF INSULATORS.
K.P.Rodionov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 4, 745-9 (1958). In Russian.

A detailed theoretical analysis is given to determine the possible behaviour of the thermal conductivity of a crystalline insulator under the action of an external pressure. The analysis depends on the postulate that in such crystals the phonons have a mean free path. A connection is established between the change in the coefficient of thermal conductivity with pressure and the analogous change in the compressibility. Various published results for the alkali halides are used to compare the theoretical predictions with experimental observations. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 4, 160-4 (1958)]. R.Bullough

TEMPERATURE DEPENDENCE OF THE THERMAL CONDUCTIVITIES OF FERROMAGNETICS AT LOW TEMPERATURE. See Abstr. 6121

ELECTRON STATES

6079 REMARKS ABOUT THE NATURE OF PROBLEMS IN REACTION KINETICS. K.W.Böer.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 2-15. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). The author draws attention to the fact that different energy-level models may account for the same set of experimental data. The constants derived from the models are in general different. The question arises for which model the constants are susceptible to microscopic theory. The paper and the discussion show that frequency factors for thermal excitation which lie between 10^8 and 10^{17} sec^{-1} have been suggested. P.T.Landsberg

6080 REMARKS ABOUT MODELS FOR REACTION KINETICS. M.Schön.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 16-31. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). General remarks which include some discussion of the necessary extensions of the usual models. Their object would be to take account of the inhomogeneities of the solid and of the absorption of incident radiation; the full details of the structure of various defects should also be considered. P.T.Landsberg

6081 REACTION-KINETIC PROBLEMS IN THE CASE OF RECOMBINATION BY ELECTRON COLLISIONS.
P.T.Landsberg.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 57-75. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). The concepts of quantum-mechanical transitions are used to arrive at appropriate equations of reaction kinetics for band—band Auger effects. The recombination via defects is also discussed. P.T.Landsberg

6082 A METHOD FOR THE QUALITATIVE DISCUSSION OF SOLUTION CURVES FOR SYSTEMS OF DIFFERENTIAL EQUATIONS. S.Oberländer.
Abhandl. Deutschen Akad. Wiss. Berlin. Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 256-64. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). Methods of solution of differential equations arising in reaction kinetics are discussed, and an alternative method is proposed which gives upper and lower bounds to the solution curves. K.G.Major

6083 ESTIMATION OF THE ROLE OF MANY-PHONON PROCESSES IN THE SCATTERING OF CONDUCTION ELECTRONS IN ATOMIC CRYSTALS. A.I.Ansel'm and I.G.Lang.
Fiz. tverdogo Tela (USSR), Vol. 3, No. 1, 308-11 (Jan., 1961).
In Russian.

Corrections and additions are made to an earlier work. (Abstr. 528 of 1960). Criteria for the negligibility of two-phonon processes are quoted. [English translation in: Soviet Physics—Solid State (USA)]. K.G.Major

6084 THE ENERGY SPECTRUM OF LOCALIZED ELECTRON LEVELS. R.Gáspár.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 110-14. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). The results of calculations by the LCAO-molecular orbital method applied to the energy of an electron in the field of a charged impurity centre are compared with results obtained by other methods The results are found to be comparable with the other calculations, and this is taken as the basis for a qualitative discussion of the energy levels of the electron in the field of several charged impurities, in analogy with the energy levels of an electron in the field of several charged particles, as in molecules and molecular ions. K.G.Major

6085 THEORY OF THE ELECTRON STATES DUE TO DISLOCATIONS. I. EDGE DISLOCATIONS.
V.L.Bonch-Bruevich and V.B.Glasko.
Fiz. tverdogo Tela (USSR), Vol. 3, No. 1, 36-46 (Jan, 1961).
In Russian.

Considers quantum-mechanically the effect of edge dislocations on the energy spectrum of electrons in a semiconductor. Deals with the spectrum as a whole and derives the number of "dislocation energy bands" and the positions of their limits for various densit of free carriers and for various temperatures. [English translat in: Soviet Physics — Solid State (USA)]. A.Tybulew

6086 THEORY OF THE ELECTRON STATES DUE TO DISLOCATIONS. II. SCREW DISLOCATIONS.
V.L.Bonch-Bruevich.
Fiz tverdogo Tela (USSR), Vol. 3, No. 1, 47-52 (Jan., 1961).
In Russian.

Discusses pure screw dislocations in a semiconductor, assu that they are macroscopically uniform and free of impurity atmosphere. The energy of interaction of carriers with dislocati is due to deformation of the lattice near dislocations. Screw dislocations is discussed. [English translation in: Soviet Physic — Solid State (USA)]. A.Tybulew

6087 THE FERMI SURFACE OF METALS. W.A.Harrison and R.W.Schmitt.
Phys. Today (USA), Vol. 14, No. 2, 20-5 (Feb., 1961).

Report of an international conference on the electronic structure of metals held at Cooperstown, New York on 22-24 Au 1960.

6088 AN EXPERIMENTAL INVESTIGATION OF X-RAY EXCITATION STATES IN SOLIDS. P.Johansson.
Ark. Fys. (Sweden), Vol. 18, Paper 18, 289-303 (1960).

When X-ray lines are recorded, the energy of the bombardi electrons is generally high above the excitation potential. In the present work recordings were made with the energy of the elect only a few electron volts above the threshold value. By compari the spectral position of such a line with the position of an ordina recorded one, a small wavelength shift was observed. The shift discussed with reference to a recently reported theory of X-ray excitation states in solids. Determinations have been made for $K\alpha_1$ line of metallic Cr and its oxide Cr_2O_3. A difference in the excitation potential between metal and oxide (chemical shift) is a reported.

6089 THE EXCITON FOR INTERMEDIATE BINDING TAK TRANSLATION INTO ACCOUNT. I.G.Zaslavskaya.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2243-7 (Sept., 1960).
In Russian.

For abstract, see Abstr. 20779 of 1960. [English translatio Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2002-5 (March, 1961)].

6090 EVIDENCE FOR THE EXISTENCE OF SURFACE EXCITONS IN TETRACENE MICROCRYSTALS.
J.Katul and A.B.Zahlan.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 101-2 (Feb. 1, 1961).

Absorption bands at 5350 and 5330 A were observed in micr crystalline films of tetracene. The position of the 5350 A band was strongly affected by the thickness of the film. The position the 5330 A band was less strongly affected, but below a certain film thickness, its intensity was strongly attenuated. This critic thickness was considerably less at 80° K than at 300° K. The ban were not observed in films with a low surface-to-volume ratio, which large flaky microcrystals were found. The absorbing film contained very small microcrystals together with larger, needle shaped, microcrystals. These bands were not sensitive to surfa oxidation. It is suggested that the bands are primarily caused b surface exciton states, although these states may be perturbed b surface imperfections, thus producing the strong dependence on film thickness. P.J.

6091 APPLICATION OF RENORMALIZATION GROUP TO THE COULOMB PROBLEM IN A SOLID.
V.L.Bonch-Bruevich.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 5, 769-75 (19
In Russian.

The theory of the renormalization group is applied to the th of screening and plasma oscillations. This may be necessary in theory of metals, when the coupling constant is of the order of u The form of the expressions derived is similar to that given by perturbation theory, but the range of validity is increased. [English translation in: Phys. Metals and Metallography (GB), V No. 5, 1-5 (1958)]. D.J.Thou

6092 THE EFFECT OF CORRELATION ON THE FREQUENCY OF PLASMA OSCILLATIONS.

Ya Kobelev.
z. Metallov i Metallovedenie (USSR), Vol. 6, No. 5, 948-51 (1958). Russian.

Expressions for corrections to the plasma dispersion law due ground-state correlations are obtained. [English translation in: ys. Metals and Metallography (GB), Vol. 6, No. 5, 179-82 (1958)]. D.J.Thouless

6093 PLASMA OSCILLATIONS OF ELECTRON GASES.

D.Pines.
ppl. to Physica (Netherlands), Vol. 26, S103-S123 (Dec. 26, 1960).

International Conference on Many-Particle Problems, Utrecht, 60 (see Abstr. 1707 of 1961). The theory of quantum plasmons is veloped by the use of the energy and momentum dependent electric constant, and their dispersion and damping are discussed. xperiments on the energy losses of fast electrons in metals are terpreted, and the validity of the free electron model is considered. e importance of surface effects is shown. Temperature effects d instabilities are discussed. D.J.Thouless

A NEW APPROACH TO THE THEORY OF THE ELECTRON AS. See Abstr. 5218

MAGNETIC FIELD AT THE NUCLEUS IN FERROMAGNETIC ETALS DUE TO THE POLARIZATION OF CONDUCTION LECTRONS. See Abstr. 6273

6094 ENERGY ANALYSIS IN KIKUCHI LINES AND IN REFLECTION OF A SILICON CLEAVAGE PLANE.

.Hartl and H.Raether.
. Phys. (Germany), Vol. 161, No. 2, 238-42 (1961). In German.

The intensity of 45 keV electrons scattered by the cleavage ane (111) was measured by a Faraday cage. By means of an ectrical retarding field, the energy distribution of these electrons as determined: the Kikuchi lines and the Bragg maxima contain, spectively, 95% and 80% of electrons with energy losses $E > 5$ eV. This high value of inelastically scattered electrons is eoretically unexplained. In terms of plasma theory there is some fficulty to reconcile the presence of electrons with one energy loss the Kikuchi lines with the small deflection which takes place in e elementary process of inelastic scattering.

6095 THE EFFECT OF TEMPERATURE ON THE ANGULAR CORRELATION OF γ-RAYS EMITTED URING ELECTRON—POSITRON ANNIHILATION IN BISMUTH.

Ya.Dekhtyar and V.S.Mikhalenkov.
okl. Akad. Nauk SSSR, Vol. 136, No. 1, 63-5 (Jan. 1, 1961). Russian.

The angular correlation of annihilation radiation produced in smuth irradiated with positrons from Na^{22} was measured at 00°K and 90°K. The maximum degree of anisotropy at these mperatures was ~15% and ~8% respectively. It is suggested that e results obtained may be interpreted in terms of single-photon nnihilation occuring more frequently at the lower temperature. English translation in: Soviet Physics—Doklady (USA)]. S.Chomet

6096 PARAMETRIC IONIC RESONANCE IN A PLASMA IN MAGNETIC FIELD. M.Andreev and M.Borisov.

.R. Acad. Bulg. Sci., Vol. 13, No. 6, 657-60 (Nov.-Dec., 1960). In ussian.

Reports observations of ionic cyclotron resonance for H$^+$ ions t a pressure of about 0.07 torr and a frequency of 1.305 Mc/s for $_0/\omega$ of 1.9 and 2.9 (ω is the resonance frequency and $\omega_0 = eH/mc$ s the cyclotron frequency). Parametric ionic resonance in a agnetic field with a cyclotron frequency about twice as high was lso observed for these ions.

6097 CYCLOTRON AND PARAMAGNETIC RESONANCE IN STRAINED CRYSTALS. G.E.Pikus and G.L.Bir.

hys. Rev. Letters (USA), Vol. 6, No. 3, 103-5 (Feb. 1, 1961).

Some possibilities for obtaining information about energy band tructures from resonance measurements in strained crystals are nvestigated theoretically: (1) in addition to the data which it was nown previously could be obtained (Abstr. 20785 of 1960; 1266 of 961), measurements of cyclotron resonance in strained Ge and Si llow measurement of the ratio of the deformation potential constants, b/d; (2) the use of strained crystals with an InSb type lattice make it possible to obtain semiconductors with spectra of a particular kind; (3) in strained crystals of p-type Si and Ge it is possible to observe a spin resonance. S.A.Ahern

6098 PENETRATION OF ELECTRONS INTO SOLIDS. I. INTENSITY OF THE ELECTRON BEAM. TRANSVERSE PATHS OF ELECTRONS. II. DEPTH DISTRIBUTION OF ELECTRONS. III. ABSORPTION OF THE ENERGY OF THE ELECTRON BEAM. A.F.Makhov.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2161-71, 2172-5, 2176-84 (Sept., 1960). In Russian.

For abstracts, see Abstr. 19765-7 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1934-41, 1942-4, 1945-51 (March, 1961)].

6099 A PHENOMENOLOGICAL THEORY OF THE CHARACTERISTIC ENERGY LOSSES OF FAST ELECTRONS IN METAL. C.B.Wilson.

Proc. Phys. Soc. (GB), Vol. 76, Pt 4, 481-8 (Oct. 1, 1960).

The characteristic energy-loss levels are derived phenomenologically for a target metal having an optical absorption band of similar energy to the free-electron plasma frequency. The various relative positions of the band and plasma frequency are considered and it is shown that the presence of an optical band introduces further particle absorption levels and may shift in either direction or completely screen out the plasma line. The theory agrees with the general experimental picture, and predicts certain results which had hitherto been unsatisfactorily accounted for, but the lack of information concerning optical absorption bands in the relevant energy region precludes any detailed comparison for a particular metal.

6100 THE ORIGIN OF THE CHARACTERISTIC ELECTRON ENERGY LOSSES IN TEN ELEMENTS. C.J.Powell.

Proc. Phys. Soc. (GB), Vol. 76, Pt 5, 593-610 (Nov., 1960).

Measurements were made of the characteristic electron energy loss spectra of beryllium, antimony, bismuth, germanium, tin, cadmium, copper, platinum, lead and calcium using the reflection technique and with 750 eV and 1500 eV primary electrons. The spectra of each element were found to consist almost entirely of combinations of two fundamental energy losses which were indentified as plasma and lowered plasma losses. A striking correlation between the lowered plasma losses and the corresponding calculated values of $\hbar\omega_p/\sqrt{2}$ was observed (ω_p is the plasma frequency), and it is suggested that the magnitude of the lowered plasma loss may be useful as an indication of the effective free electron density. If the specimen oxidized appreciably, the intensity of the lowered plasma loss decreased rapidly and a new modified lowered plasma loss appeared. It is considered that the present results are characteristic of clean metal surfaces and that many of the discrepancies in past work can be explained by the presence of surface contaminants.

6101 CHARACTERISTIC ELECTRON ENERGY LOSS SPECTRA OF THE TRANSITION METALS, Ti TO Cu.

J.L.Robins and J.B.Swan.
Proc. Phys. Soc. (GB), Vol. 76, Pt 6, 857-69 (Dec. 1, 1960).

The characteristic electron energy-loss spectra of the elements of the first group of transition metals, Ti to Cu, were obtained using the reflection technique. In the spectrum of each metal one loss peak was identified as a plasma loss, and another, except in Ti and V, as a lowered plasma loss. Two other series of loss values were associated with ionization of the M$_1$ and M$_{2,3}$ shells, whilst a peak observed with most metals at about 5 eV loss could be ascribed to ionization of the M$_{4,5}$ shell. Other losses were interpreted as due to interband transitions, or as combinations or multiples of other loss values. The plasma loss values were found to agree with the theoretical values of $\hbar\omega_p$, assuming all 3d- and 4s-electrons to be "free", for the first elements of the series and then to fall below the predicted values.

6102 ON THE COLLECTIVE ENERGY LOSS MECHANISM OF ELECTRONS PASSING THROUGH SOLIDS. M.Watabe.

Progr. theor. Phys. (Japan), Vol. 22, No. 3, 447-8 (Sept., 1959).

The high-density limit theory of Sawada et al. (Abstr. 399 of 1958) is used to calculate the transition probability of an incident fast electron being scattered by exciting the electron gas into the one-plasmon state. K.G.Major

6103 ASPHERICAL 3d ELECTRON DISTRIBUTION IN Ni^{++}.
H.A.Alperin.
Phys. Rev. Letters (USA), Vol. 6, No. 2, 55-7 (Jan. 15, 1961).

By using unpolarized neutrons the magnetic form factor for Ni^{2+} in a single crystal of NiO was obtained. Values of the form factor when plotted against sin θ/λ do not lie on a smooth curve and this demonstrates the asphericity of the unpaired 3d electrons in Ni^{2+}. To compare theory and experiment it is necessary to suppose that the 3d charge distribution for Ni^{2+} is more compact in the solid than in the free atom in contrast to the case of Mn^{2+}. The results are also compared with the theory of Watson and Freeman (Abstr. 20769-70 of 1960). D.J.Oliver

DEFECT PROPERTIES

6104 EQUILIBRIUM THERMODYNAMIC PROPERTIES OF A VACANCY IN A F.C.C. LATTICE WITH CENTRAL INTERACTION.
G.F.Nardelli and A.R.Chiarotti.
Nuovo Cimento (Italy), Vol. 18, No. 6, 1053-71 (Dec. 16, 1960).

The influence of a vacant lattice site on the thermodynamic equilibrium properties of crystals is investigated at various temperatures ranging from zero to the melting point. The change of vibrational properties are evaluated by means of an Einstein model. The study of the elastic relaxation is extended to a vibrating lattice, and the vibrational free energy is evaluated taking into account the displacement field. The "image forces" due to the vacancy are discussed including the cubic tensors in the expression of the potential energy. Numerical results are reported for crystals of inert gases.

6105 QUENCHING VACANCIES IN ALUMINUM.
T.Kino and S.Kabemoto.
J. Sci. Hiroshima Univ. A (Japan), Vol. 24, No. 2, 287-96 (Oct., 1960).

High-purity aluminium wires were quenched in water from 290-550°C. A decrease in resistivity by annealing at a room temperature after quenching was observed, which was interpreted as being due to quenching vacancies. From the decrease in resistivity for different quenching temperatures, an energy of formation for a vacancy was estimated as 0.77 ± 0.03 eV. The activation energy for the decrease in resistivity was obtained from the isothermal annealing curves for various quenching temperatures; it was from 0.3 to 0.9 eV and depended on the vacancy concentration and also on the quenching temperature, even for the same concentration of vacancies. The observations were explained by supposing that monovacancies, divacancies and large vacancy clusters that are difficult to move coexist in the quenched aluminium.

6106 STACKING FAULTS IN COLD-DEFORMED NICKEL AND NICHROME.
Ya.D.Vishnyakov and S.S.Gorelik.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 841-52 (Dec., 1960). In Russian.

Displacement of X-ray diffraction lines gave the density of stacking faults in nickel and Nichrome powders (deformation was produced by pulverization). The densities were about 1% for nickel and about 2% for Nichrome. Dimensions of regions ("blocks") from which X-rays are reflected coherently were considerably greater when they were calculated with allowance for the effect of stacking faults on broadening of X-ray lines. A.Tybulewicz

IMPURITY SHIFT OF PURE QUADRUPOLE RESONANCE FREQUENCY. See Abstr. 6438

DIELECTRIC PROPERTIES OF SOLIDS IN RELATION TO IMPERFECTIONS. See Abstr. 6188

THE ELECTRICAL EFFECTS OF DISLOCATIONS IN SEMICONDUCTORS. See Abstr. 6136

ELECTRON STATES DUE TO DISLOCATIONS. See Abstr. 6085

DISLOCATION ETCH PITS ON BISMUTH TELLURIDE CRYSTALS. See Abstr. 6492

6107 X-RAY MEASUREMENT OF TWIN FAULTING IN FACE-CENTRED CUBIC METALS.
B.E.Warren.
Austral. J. Phys., Vol. 13, No. 2a, 384-90 (July, 1960).

Solid State Physics Conference (see Abstr. 17864 of 1960). It was shown by Paterson that in a cold-worked face-centred cubic metal, deformation faults produce a peak shift, and twin faults produce asymmetry. If the peak shape is represented by a Fourier series, the asymmetry is expressed by the sine terms. However, the evaluation of the sine coefficients is difficult, due to overlappi of the tails of neighbouring reflections and uncertainty in the peak origin. In this paper, a method is developed which combines the tails of the (111) and (200) reflections. This allows a determinati of the twin fault probability in face-centred cubic metals which is more nearly independent of overlapping of the tails and choice of peak origin.

6108 HIGH-ANGLE TILT BOUNDARY — A DISLOCATION CORE MODEL.
J.C.M.Li.
J. appl. Phys. (USA), Vol. 32, No. 3, 525-41 (March, 1961).

The dislocation model of a symmetric tilt boundary is modifie to take into consideration the stress field of the cores of the dislocations. It is found that such modification enables discussion of many properties of high-angle tilt boundaries including porosity, strain energy, intergranular fracture, grain boundary shearing, void formation, preferential melting, preferential diffusion, bound migration, segregation, precipitation, amorphous behaviour, conti uous and discontinuous transition, etc., in terms of the interactio among the cores of the dislocations and the properties of the core themselves. This is a first attempt to devise a working model capable of interpreting all the properties of grain boundaries. Unlike other models which are designed to have a few particular properties in a limited angular range, this model has the advanta of reducing to the dislocation model at low angles and of providin for amorphous behaviour at high angles. The characteristic of a grain boundary of behaving as an ordered liquid of lower density i pointed out. The picture of a high-angle boundary is that it conta an equilibrium number of jogs which control many mechanical as well as thermochemical properties.

6109 MODELS OF GRAIN BOUNDARIES IN THE DIAMOND LATTICE. II. TILT ABOUT ⟨001⟩ AND THEORY.
J.Hornstra.
Physica (Netherlands), Vol. 26, No. 3, 198-208 (March, 1960).

For Pt I, see Abstr. 7899 of 1960. Models are presented for large-angle grain boundaries with a ⟨001⟩ tilt axis. For all angle of tilt, dislocations without dangling bonds can be used in the construction of these models. One model may be considered eith as an array of edge dislocations or as an array of 45° dislocation In the last section the crystallography of regular grain boundarie is discussed, the grain-boundary index is introduced and the appl cation of the transformation matrix to grain-boundary problems i illustrated.

Diffusion

6110 THE EFFECT OF MOSAIC STRUCTURE ON DIFFUSI OF ZINC IN ALUMINIUM MONOCRYSTALS.
D.E.Ovsienko and I.K.Zasimchuk.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 743-9 (Nov 1960). In Russian.

Dimensions of mosaic blocks and angles of tilt between them were altered by altering the conditions of growth of aluminium mo crystals. Diffusion of zinc in such monocrystals was studied usin a radioactive tracer. It was found that increase of the mosaic bl dimensions and the angles of tilt accelerated diffusion of zinc. A.Tybulew

6111 DIFFUSION OF CADMIUM INTO GALLIUM ARSENID
F.A.Cunnell and C.H.Gooch.
Nature (GB), Vol. 188, 1096 (Dec. 24, 1960).

Measurements of the diffusion profile were made using Cd^{115} The profile shows a rapid decrease in concentration with distance just below the surface, and the diffusion coefficient is 3×10^{-12} cm^2/sec in this region. About 30 μ below the surface the Cd concentration starts increasing with distance, rises to a maximu and then shows a gradual decrease. No explanation has yet been found for this anomalous behaviour. C.Hils

6112 IDENTIFICATION OF THE DIFFUSION OF IRON IONS IN MAGNETITE EMPLOYING MARKERS. D.Fuller.
Acta metallurgica (Internat.), Vol. 8, No. 10, 743-4 (Oct., 1960).

Whem Armco iron is oxidized, impurities concentrate at the Fe/FeO interface. These impurities (oxides of Ni, Cu and Co) are insoluble in Fe or its oxides. If the FeO is removed and the iron oxidized further, the impurities form a permanent layer marking the original oxide/atmosphere interface. Measurement of their distance (M) from the free surface as the thickness (e) of Fe_3O_4 grows, gives the result that, at temperatures 600-1200° C, e/M tends to the value of 4 as the time of oxidation increases. This is consistent with the theory that the oxidation of FeO to Fe_3O_4 is by diffusion of Fe ions only through the layer of Fe_3O_4. A.F.Brown

6113 MEASUREMENT OF DIFFUSION COEFFICIENTS IN OXIDES.
.M.Klotsman, A.N.Timofeev and I.Sh.Trakhtenberg.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 732-5 (Nov., 960). In Russian.

A radioactive-tracer study of diffusion in Fe_3O_4 monocrystals nd sintered powders at 850-1075° C showed that reliable volume iffusion results are obtained with the sintered material only near he melting point of Fe_3O_4. This is because diffusion in sintered xides is affected by diffusion along free surfaces of pores.
A.Tybulewicz

6114 PERMEATION OF HYDROGEN AND DEUTERIUM THROUGH A NICKEL MEMBRANE IN THE 250-600° C
EMPERATURE RANGE. Yu.I.Belyakov and N.I.Ionov.
Zh. tekh. Fiz. (USSR), Vol. 31, No. 2, 204-10 (Feb., 1961). In Russian.

Permeation of H and D through a thin (0.395 mm) Ni membrane was studied with the aid of a pulsed mass-spectrometer. The emperature dependence of permeability, diffusivity, and solubility of H and D in Ni was determined. It was established that there is a udden change in the diffusion characteristics of the Ni–H system at he Curie point. The differences in the behaviour of the two isotopes tudied were attributed to the difference in the dissociation energies of the H_2 and D_2 molecules and in the characteristic oscillation frequencies. [English translation in: Soviet Physics–Technical Physics (USA)]. M.H.Sloboda

6115 SELF-DIFFUSION OF ZIRCONIUM IN SOME BINARY AND TERNARY ALLOYS BASED ON ZIRCONIUM.
.S.Lyashenko, V.N Bȳkov and L.V.Pavlinov.
iz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 756-62 Nov., 1960). In Russian.

Reports a study of self-diffusion of zirconium in Zr–Nb alloys ith up to 31.1% by weight of Nb and in ternary alloys with 25% Nb, ontaining one of the following: 3% Mo, 2.8% Sn, and 0.6% Cr. The iffusion coefficients were found using a radioactive tracer Zr^{95} at 00-1200° C. Alloying of zirconium with niobium raised the diffusion ctivation energy and lowered the diffusion coefficient. Further lloying with molybdenum, tin or chromium increased the activation nergy still further. The lowest diffusion velocity was obtained in n alloy containing zirconium, 28% Nb and 3% Mo. A.Tybulewicz

6116 THE EFFECT OF IRON AND NICKEL IMPURITIES ON SELF-DIFFUSION IN α-ZIRCONIUM.
V.S.Lyashenko, V.N.Bȳkov and L.V.Pavlinov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 727-31 Nov., 1960). In Russian.

Addition of iron and nickel in amounts up to 0.4% by weight lowered the self-diffusion coefficient in α-zirconium by a factor of 2-3 (the coefficient was measured between 650 and 830° C using the radioactive tracer Zr^{95}). A.Tybulewicz

6117 THE EFFECT OF THE TEMPER TEMPERATURE ON THE DIFFUSION AND SOLUBILITY OF HYDROGEN IN
ARDENED STEEL. E.P.Nechai, K.V.Popov and L.S.Panenkova.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 838-40 Dec., 1960). In Russian.

Room temperature studies showed that the rate of diffusion of ydrogen was inversely proportional to the steel hardness, but the mount of hydrogen absorbed, during cathodic polarization in an lectrolyte, was independent of the steel hardness and microtructure. A.Tybulewicz

6118 THE INFLUENCE OF PRESSURE ON THE MEAN TIME OF STAY OF INTERSTITIAL CARBON IN IRON.
A.J.Bosman, P.E.Brommer, L.C.H.Eijkelenboom, C.J.Schinkel and G.W.Rathenau.
Physica (Netherlands), Vol. 26, No. 7, 533-8 (July, 1960).

The influence of the hydrostatic pressure on the mean time of stay of interstitial carbon atoms in α-iron was determined by measuring the time decrease of permeability. This influence was found to be very small at temperatures from 239°K up to 253°K. The corresponding activation volume is negligible. It is concluded that Keyes' semi-empirical relationship between activation energy and activation volume does not hold for this case, no more than for solid solutions of nitrogen in α-iron.

Colour Centres

6119 RADIATION-INDUCED DEFECTS IN LEAD SILICATE GLASS.
R.S.Barker, D.A.Richardson, E.A.G.McConkey and R.E.Yeadon.
Nature (GB), Vol. 188, 1181 (Dec. 31, 1960).

Experiments are described which show that exposure of glass to γ-radiation not only traps electrons in defects to form colour centres as was suggested previously (Abstr. 16074 of 1960) but also creates new defects of this type in the glass. D.M.Schlapp

Radiation Effects

6120 SOME RECENT DEVELOPMENTS IN THE THEORY OF RADIATION DAMAGE. G.H.Vineyard.
Energia nucleare (Italy), Vol. 8, No. 1, 9-15 (Jan., 1961).

The structural modifications of solids being irradiated by nuclear projectiles have to be taken into account in the design of nuclear reactors, and the accurate description of these phenomena is required. The present state of knowledge on this topic is briefly reviewed and the theoretical work which is being carried out at Brookhaven National Laboratory is summarized.

RADIATION-INDUCED DEFECTS IN LEAD SILICATE GLASS. See Abstr. 6119

THE EMBRITTLEMENT OF MOLYBDENUM BY NEUTRON IRRADIATION. See Abstr. 3993

NEUTRON-IRRADIATION EFFECTS ON THE INFRARED ABSORPTION OF DIAMONDS. See Abstr. 6211

ELECTRICAL PROPERTIES OF SOLIDS

(Superconductivity is included under Low-Temperature Physics)

6121 A THEORY OF THE TEMPERATURE DEPENDENCE OF THE ELECTRICAL AND THERMAL CONDUCTIVITIES OF FERROMAGNETICS AT LOW TEMPERATURES.
Sh.Sh.Abel'skii and E.A.Turov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 801-6 (Dec., 1960). In Russian.

The electrical resistance of ferromagnetics due to scattering of conduction electrons on spin waves is calculated as a function of temperature. It is assumed that the dispersion law of conduction electron energy is isotropic but dependent on the direction of spin. Assuming a quadratic dispersion law the thermal conductivity is calculated as a function of temperature and related to the appropriate component of the electrical conductivity. A.Tybulewicz

6122 A THEORY OF RESIDUAL ELECTRICAL RESISTANCE IN MULTICOMPONENT ALLOYS CAPABLE OF ORDERING, WITH ALLOWANCE FOR LATTICE DISTORTIONS DUE TO DIFFERENCES IN DIMENSIONS OF ATOMS.
A.I.Nosar' and A.A.Smirnov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 807-17 (Dec., 1960). In Russian.

Discusses the residual electrical resistance of multicomponent substitutional alloys of non-transition metals, which are capable of ordering. The residual resistance is considered as a function of composition and long-range order parameters with allowance for lattice distortions due to differences in dimensions of the component atoms. Correlation effects are not dealt with. The allowance for lattice distortions is made using an elastic medium model. A.Tybulewicz

6123 COLD WORK AND SUBSEQUENT ELECTRICAL RESISTIVITY INCREASES IN PURE ALUMINUM. H.R.Peiffer and F.Stevenson.
Acta metallurgica (Internat.), Vol. 8, No. 7, 494-5 (July, 1960).

Data obtained by Peiffer is compared with earlier work by Wintenberger (Abstr. 15856 of 1960) who showed that the increase in resistivity $\Delta\rho$ produced by cold-working aluminium is given by the relation $\Delta\rho = c\epsilon$, where ϵ is the elongation and c is a constant. Using Wintenberger's data, it is deduced that following deformation at 78°K, about 58% of the extra resistivity is attributable to point defects and therefore recoverable at room temperature. Peiffer obtained 62% recovery with material of comparable purity. However, there is a disagreement between the absolute magnitudes of the constant c calculated from the two sets of data. This is attributed to the initial condition of the aluminium since Wintenberger used annealed material and Peiffer cold-drawn aluminium. A.E.Kay

6124 RESIDUAL RESISTANCE OF COPPER ANNEALED IN AN O_2 ATMOSPHERE. R.L.Dolecek and D.J.Schultz.
Acta metallurgica (Internat.), Vol. 8, No. 9, 664-5 (Sept., 1960).

Measurements of the residual resistivity (ρ) at 4.2°K were made on high-purity polycrystalline copper wire which was annealed for 4 hours at temperatures above 400°C in either vacuum (~ 10^{-5} mm Hg), or air at pressures around 20 μ Hg. The resistivity at 4.2°K was found to depend on the annealing temperature: when oxygen was present the resistivity ratio $\rho_{273^{\circ}K}/\rho_{4.2^{\circ}K}$ varied from 300 at 800° C to a maximum of 1000 at about 500°C and then decreased rapidly at lower temperatures. It is suggested that the oxygen neutralizes certain impurities which act as scattering centres, but when present in excess it adds to the scattering centres. A.E.Kay

6125 ELECTRICAL RESISTANCE ANOMALIES IN BRASSES AND ALUMINIUM BRONZES.
A.A.Presnyakov, L.I.Dautova and Yu.F.Klyuchnikov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 676-80 (Nov., 1960). In Russian.

Measurements of the electrical resistance of deformed brasses and aluminium bronzes (α-type Cu–Zn and Cu–Al solid solutions respectively) after quenching and annealing showed that the resistance anomalies are related to ordering of these solid solutions. A.Tybulewicz

6126 ELECTRICAL RESISTANCE ANOMALIES PRODUCED BY LOW-TEMPERATURE ANNEALING OF COLD-ROLLED Fe_3Al ALLOY. Ya.P.Selisskii.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 829-34 (Dec., 1960). In Russian.

The electrical resistance of Fe_3Al was studied as a function of the degree of cold deformation (rolling) and the annealing temperature and duration. With increase of the duration of annealing after strong deformation the resistance rose, passed through a maximum and then fell again. Increase of the resistance was due to a diffusion process stimulated by the non-uniform stress field produced by cold rolling. The diffusion process produced Cottrell atmospheres. The accompanying changes in short-range order could alter the electron energies and reduce the number of conduction electrons. The lowering of the resistance after passing through a maximum was due to the appearance of long-range order. A.Tybulewicz

SURFACE RESISTANCE OF METAL CRYSTALS.
See Abstr. 6201

STUDY OF THE EFFECT OF THERMOMAGNETIC TREATMENT ON THE ELECTRICAL RESISTIVITY OF SUPERLATTICE-FORMING SOFT MAGNETIC ALLOYS. See Abstr. 6533

6127 THE RESISTIVITY TEMPERATURE COEFFICIENT OF THIN FILMS OF TIN. M.Oncescu.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 2, 157-62 (1957). In Roumanian.

The variation with temperature of the resistivity of thin films of tin was examined using films of various thicknesses, obtained vacuum evaporation of the metal. Results are shown graphically for films deposited on supports at 77° and 293° K. The film thick ses ranged from 35 to 1700 A and the temperature range covered was from 80° to 300° K. The coefficient increased from –0.021 deg for the thinnest film to +0.004 deg^{-1} C for the thickest. A table i given of the values of the resulting resistivity temperature coefficients for thin films of tin. S.Weintr

6128 INFLUENCE OF [PERIODIC-TABLE] NEIGHBOURS IRON ON THE HALL EFFECT OF IRON-RICH MIXE CRYSTALS. W.Jellinghaus and M.P.de Andrés.
Ann. Phys. (Germany), Vol. 7, No. 3-4, 189-200 (1961). In Germ

The positive ordinary Hall coefficient, R_0, of mixed crystals iron with small concentrations of neighbouring elements is alway greater than that of the pure metal. The value of R_0 rises linea with the atomic number of the alloying element in crystals conta ing 99 at.% iron and 1 at.% of the elements Co, Ni or Cu. R_0 also rises monotonically, but non-linearly, with decreasing atomic numb of the alloying elements from Mn to Ti. The influence of Si is only slightly greater than that of Ti. The extraordinary Hall coefficient, R_1, and the resistivity increase in a somewhat simi manner in these alloys. Notable deviations in these constants fr the sequence in the periodic table were found. R.Pan

6129 THERMAL AND ELECTRICAL PROPERTIES OF NUCLEIC ACIDS AND PROTEINS. J.Duchesne, J.Depireux, A.Bertinchamps, N.Cornet and J.M.van der Kaa.
Nature (GB), Vol. 188, 405-6 (Oct. 29, 1960).

Calf thymus and herring sperm deoxyribonucleic acid, rabbi myosin and actomyosin as well as collagen were prepared as pellets under a pressure of 700 kg cm^{-3}. All these substances w characterized by absorption lines in the frequency range 33-35 M so it appears that piezoelectricity is a property of proteins and nucleic acids (Abstr. 5567, 6120 of 1955). The frequency shifts $\Delta (= -\nu^{-1} d\nu/dt)$ over a temperature range 77°-296° K were, for th above substances, respectively, 50, 56, 85, 100 and 47 × 10^{-6} uni In the case of deoxyribonucleic acid the absorption lines disappe at approximately 323° K. The electrical conductivity of these su stances was measured on a pellet 1.3 cm diameter × 0.3 cm thic The conductivity varied with temperature according to the equat for semiconductors:

$$\sigma = \sigma_0 \exp(-E/2KT)\,\Omega^{-1}\ \mathrm{cm}^{-1}.$$

The activation energies were: herring sperm D.N.A. and calf thy D.N.A., 1.80 eV; myosin 1.75 eV; collagen 0.9 eV. The values are considered very accurate. Irradiation of herring sperm D.N.A. 10^8 r of γ-rays from Co^{60} produced no measurable change in its semiconductivity. J.I

6130 D.C. FIELD CHARACTERISTICS OF LAMINATED PLASTICS. D.R.Bhawalkar and S.M.Khanna.
Z. angew. Phys. (Germany), Vol. 13, No. 2, 102-4 (Feb., 1961).

The current–voltage characteristic of a specimen of phenol resin–paper laminate is determined and the nonlinear behaviour commented on. K.W.Ples

Semiconductors

6131 INTERNATIONAL CONFERENCE ON PHYSICS OF SEMICONDUCTORS. Ch.B. Lushchik.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 797-8 (Dec., 1960). In Russian.

Summarizes briefly the papers on excitons and ionic crysta presented at the International Conference on Physics of Semiconductors held on August 29-September 2, 1960, in Prague. [E lish translation : Optics and Spectrosc. (USA), Vol. 9, No. 6, 42 (Dec., 1960)]. A.Tybule

6132 NEGATIVE EFFECTIVE MASSES IN SEMICONDUCT H.Krömer.
Progress in semiconductors. Vol. 4, (See Abstr. 5007 of 1961) p. 1-34.

This review paper deals with the study of negative effective mas at degenerate band edges associated with warped energy surface in semiconductors. The theoretical concepts leading to the introduction of an effective mass are summarized and the approp terminology is defined. Types of degenerate band structure are

tegorized. A study of the distribution of negative effective masses the valence band of germanium is described, and the effect of in—orbit splitting is briefly considered. The possible application a hypothetical negative-mass amplifier is discussed. 23 refs.
J.B.Birks

6133 THEORY OF AVALANCHE MULTIPLICATION IN NON-POLAR SEMICONDUCTORS. J.Yamashita.
rogress in semiconductors. Vol. 4 (see Abstr. 5007 of 1961) . 63-94.

A theory of electron multiplication in non-polar crystals is eveloped on the basis of the Boltzmann equation of transport henomena. After a short qualitative discussion of hot electrons, e Boltzmann equation for hot electrons and a theory of electron ultiplication are derived. The data on avalanche breakdown in —n junctions are considered, and discussed in terms of the Bloch quation with space coordinate. The final section deals with valanche light emission, impact impurity ionization, and effects f magnetic field and of orientation. 32 refs. J.B.Birks

6134 INTERNAL FIELD EMISSION.
A.C.Chynoweth.
rogress in semiconductors. Vol. 4 (see Abstr. 5007 of 1961) . 95-123.

Reviews the theoretical treatments of internal field emission FE) and considers the experimental evidence for the occurrence f the five basic IFE processes that have been postulated. After an ccount of the theoretical approach to IFE, its relevance to ielectric breakdown, field ionization of localized levels, field mission at electrodes, electroluminescence, tunnelling between calized centres, point-contact rectifiers and p—n junctions is iscussed. 98 refs. J.B.Birks

6135 NOISE IN SEMICONDUCTORS.
D.Sautter.
rogress in semiconductors. Vol. 4 (see Abstr.5007 of 1961) . 125-53

The experimental data, mainly on germanium, and theoretical oncepts of noise in homogeneous semiconductors are reviewed. opics discussed include thermal noise, generation-recombination nd shot noise, and the experimental results and theories of inverse requency (1/f) noise. 63 refs. J.B.Birks

6136 THE ELECTRICAL EFFECTS OF DISLOCATIONS IN SEMICONDUCTORS. W.Bardsley.
rogress in semiconductors. Vol. 4 (see Abstr. 5007 of 1961) p. 155-203

The ways in which dislocations can be generated — during rowth, by bending, twisting, compression and indentation, and by ensile deformation — are discussed. The electronic energy levels ue to dislocations, and the associated electrical effects are onsidered. The effects at various types of boundaries — lineage, edium-angle, large-angle and grain — are treated. 137 refs.
J.B.Birks

6137 NON-CRYSTALLINE, AMORPHOUS AND LIQUID ELECTRONIC SEMICONDUCTORS.
.F.Ioffe and A.R.Regel.
rogress in semiconductors. Vol. 4 (see Abstr. 5008 of 1961).p. 237-91

The crystalline structure of solids and the presence of long-ange order are not necessary conditions for the occurrence of ypical semiconducting properties. The consideration of liquid nd vitreous semiconductors requires a wider basis than the band heory. The liquid semiconductors considered include metallic xides and sulphides, substances with diamond and zinc-blende type tructures, substances with linear systems of homopolar bonds Te, Se, S), substances with a layer structure, substances with aCl-type structure, and intermetallic compounds. 194 references.

6138 THE ELECTRICAL PROPERTIES OF SEMICONDUCTOR SURFACES. T.B.Watkins.
rogress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961) . 1-52.

Review. Considers a model of a semiconductor surface and e basic theoretical considerations of the space charge, the surface nductance and the fast states. Field effect measurements on the st and slow states and at high frequencies, the channel effect, easurements associated with the Schrieffer correction, and easurements on clean surfaces are reviewed. The applications metal—semiconductor contacts, the effect of the surface on verse currents, inverse frequency (1/f) noise, and stable surfaces e discussed. 99 refs. J.B.Birks

6139 THE CHEMICAL BOND IN SEMICONDUCTORS.
E.Mooser and W.B.Pearson.
Progress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961) p. 103-39.

The concept of the semiconducting bond, in the valence bond and simple molecular orbital descriptions, and its application to the prediction of semiconductivity are described. The crystal chemistry of semiconductors is discussed in terms of structures based on close-packed arrays of anions, and the directional character of covalent bonds and the composition of normal valence compounds. Extensive data are presented on the dependence of energy gaps and charge carrier mobilities on bonding. 74 refs. J.B.Birks

6140 THE TRUE LIFETIME AND THE POSSIBLE MECHANISM OF INELASTIC SCATTERING OF CARRIERS IN SEMICONDUCTORS. S.M.Ryvkin.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 180-98. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). A "true" mean lifetime of an electron in a band is defined, and is compared with more conventional definitions. It is, however, granted that it is the more usual lifetimes which seem to be appropriate to the more common experimental situations.
P.T.Landsberg

6141 CONDUCTIVITY IN ELECTRON—HOLE JUNCTIONS IN REVERSE DIRECTION. V.I.Fistul' and O.B.Orzhevskii.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2214-17 (Sept., 1960). In Russian.

For abstract, see Abstr. 20880 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1976-9 (March, 1961)].

6142 DEFORMATION POTENTIAL THEORY OF SEMICONDUCTORS WITH COMPLEX BAND STRUCTURE.
G.L.Bir and G.E.Pikus.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2287-2300 (Sept., 1960). In Russian.

For abstract, see Abstr. 1030 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2039-51 (March, 1961)].

6143 MACROSCOPIC PHYSICS OF SURFACE RECOMBINATION IN SEMICONDUCTORS. A.C.Sim.
J. Electronics and Control (GB), Vol. 10, No. 2, 117-26 (Feb., 1961).

It is shown that the concept of surface recombination velocity, commonly used to describe surface properties of transistor materials, is only valid when its magnitude is small compared with the diffusion velocity. An improved model in which the excess charge-carrier lifetime is supposed to vary with position is analysed, and it is found that the apparent recombination velocity can depend markedly on the experimental conditions when the diffusion length is short as with indium antimonide. It is also found that the common method of measuring this velocity with thin slice material is not valid when the effect is too large. A brief inspection of the possible influence of electric field shows that it could dominate in determining the magnitude of the velocity.

6144 THE CALCULATION OF BULK LIFETIME AND SURFACE RECOMBINATION RATE OF CURRENT CARRIERS. V.N.Dobrovol'skii and V.G.Litovchenko.
Pribory i Tekh. Eksper. (USSR), 1959, No. 6, 78-80 (Nov.-Dec.). In Russian.

Nomograms are presented for calculating the bulk lifetime (τ) and surface-recombination rate (s) from two values of the effective lifetime corresponding to two sample thicknesses. Conditions are established which, if fulfilled, should allow one to measure τ and s by the methods of Navon et al. (Abstr. 849 of 1953) and Many (Abstr. 3482 of 1954) or others similar to them, for any value of s. [English translation in: Instrum. exper. Tech. (USA), No. 6, 936-9 (Nov.-Dec., 1959; publ. Sept., 1960)].

THERMAL CONDUCTIVITY OF SEMICONDUCTORS.
See Abstr. 6077

MAGNETO-OPTICAL PHENOMENA IN SEMICONDUCTORS.
See Abstr. 6203

Semiconducting Materials

6145 RESISTIVITY CALCULATIONS FOR SEMICONDUCTOR CRYSTALS GROWN BY THE CZOCHRALSKI TECHNIQUE. B.Pratt and M.Y.Ben-Sira.
Bull. Res. Coun. Israel, Vol. 8C, No. 3, 103-8 (Oct., 1960).

The deviation of a practical formula for the calculation of the top resistivity of semiconductor single crystals grown by the Czochralski technique is presented. This formula contains measurable quantities only, e.g. mass, resistivity, mobility and segregation coefficients. It is shown that, in practice, using the top resistivity is sufficient to bring the crystal into the required resistivity range.

6146 THE ATTAINMENT OF CLEAN SURFACES BY BREAKING CRYSTALS IN ULTRA-HIGH VACUUM.
P.C.Banbury, G.A.Barnes, D.Haneman and E.W.J.Mitchell.
Vacuum (GB), Vol. 9, 126-7 (May, 1959; publ. Dec., 1960).

Two experiments are described with the object of determining some of the electronic properties of semiconductor surfaces produced by fracture in high vacuum. In one experiment the photoelectric emission was measured from freshly broken indium antimonide and gallium arsenide, and from cleaved bismuth telluride. The surfaces were produced and the measurements carried out in sealed-off tubes pumped by ionization gauges. The pressures achieved in these tubes were between 10^{-7} and 10^{-9} mm Hg. In the other experiment, the transverse mobility of induced surface charge and the photoconductivity were investigated on germanium surfaces obtained by cleavage in a vacuum of order 10^{-10} mmHg. This vacuum was obtained in a continuously pumped system with a mercury diffusion pump and ionization gauge. Details of the two kinds of tube are given.

6147 EFFECT OF COPPER IMPURITY ATMOSPHERES AT DISLOCATIONS ON RECOMBINATION IN GERMANIUM.
S.G.Kalashnikov and A.K.Mednikov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2058-65 (Sept., 1960). In Russian.

For abstract, see Abstr. 2407 of 1961. [English translation in: Soviet Physics—Solid State (USA), 1847-52 (March, 1961)].

6148 THE TEMPERATURE DEPENDENCE OF THE CARRIER LIFETIME IN GERMANIUM IN THE INTRINSIC-CONDUCTION REGION. T.V.Mashovets and S.M.Rȳvkin.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 70-8 (1959). In Russian.

Derives a theoretical temperature dependence of the carrier lifetime for the case of recombination at simple traps using Shockley and Read's statistical theory (Abstr. 8183 of 1952). Describes experiments on n-type germanium at 135-400°K, which confirmed the derived theoretical dependence. A.Tybulewicz

6149 DONOR CONCENTRATION AT THE SURFACE OF A DIFFUSED N-TYPE LAYER ON P-TYPE GERMANIUM. R.Glang and W.B.Easton.
J. Electrochem. Soc. (USA), Vol. 107, No. 9, 758-63 (Sept., 1960).

Four methods of evaluating the donor concentration at the surface of a diffused n-type layer on p-type germanium are investigated. All methods assumed a complementary error function (erfc) distribution in the diffused layer. The methods required the use of experimental data for junction depth and sheet resistivity, and of published data for diffusion coefficients of group V elements and electron mobilities in germanium. The methods were applied to calculate the donor concentrations at the surfaces of a number of diffused samples. Under diffusion conditions, which were expected to result in an erfc impurity distribution, the actual concentration profile in the vicinity of the junction was shown to deviate from the erfc law. Due to this deviation, one of the methods of calculating the surface concentrations agreed within a factor of 2 or 3. The disagreement is mainly caused by lack of precise information in respect to the electron mobilities in the diffused layer. Therefore, all the methods represent approximations only.

6150 HOT CARRIERS IN GERMANIUM.
B.V.Rollin and J.M.Rowell.
Proc. Phys. Soc. (GB), Vol. 76, Pt 6, 1001-2 (Dec., 1960).

For a p-type doped germanium sample, the mobility μ of hot carriers produced by irradiation with room temperature radiation is greater than for carriers in thermal equilibrium and shows a different temperature dependence. For the hot carriers, μ is constant for lattice temperatures less than about 14°K and decreases above this temperature where the predominant mechanism for energy los by the carriers is by interaction with phonons. For an n-type samp the mobility and its temperature dependence was different for two types of irradiation. It is suggested that, with room temperature radiation, the mobility is limited by impurity scattering but that intrinsic radiation ($\lambda < 1.8\ \mu$) reduces the number of ionized impur ties. Some information is also obtained about the capture cross-section for holes by ionized impurities. D.J.Olive

6151 MECHANISM OF RECOMBINATION-CENTRE FORMATION IN GERMANIUM AND SILICON QUENCHED FRO LOW TEMPERATURES. L.S.Milevskii.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2218-27 (Sept., 1960). In Russian.

For abstract, see Abstr. 2408 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1980-7 (March, 1961)].

6152 VOLUME RECOMBINATION OF CARRIERS IN N-TYPE SILICON CONTAINING RADIATION DEFECT
G.N.Galkin, N.S.Rȳtova and V.S.Vavilov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2025-30 (Sept., 1960). In Russian.

For abstract, see Abstr. 2409 of 1961. [English translation i Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1819-23 (March, 1961)].

6153 EFFECT OF HEAT TREATMENT ON THE MINORITY CARRIER LIFETIME IN SILICON.
V.A.Atsarkin and E.Z.Mazel'.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2089-94 (Sept., 1960). In Russian.

For abstract, see Abstr. 1064 of 1961. [English translation in Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1874-8 (March, 1961)].

6154 THE EFFECT OF QUENCHING ON THE MINORITY-CARRIER LIFETIME IN SILICON. L.S.Milevskii.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2158-60 (Sept., 1960). In Russian.

For abstract, see Abstr. 1065 of 1961. [English translation i Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1931-3 (March, 1961)].

6155 AN INVESTIGATION OF FAST SURFACE STATES OF SILICON. V.G.Litovchenko.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 83-7 (1959). I Russian.

Reports a study (in ~10^{-6} mm Hg vacuum) of some parameter of fast surface states of silicon (etched in CP-4) with 30-250 ohm resistivity and a volume carrier lifetime of 200-4000 μsec.
A.Tybulewi

6156 PREPARATION OF UNIFORM RESISTIVITY N-TYPE SILICON BY NUCLEAR TRANSMUTATION.
M.Tanenbaum and A.D.Mills.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 171-6 (Feb., 1961).

By the capture of a thermal neutron, the natural isotope Si^{30} c be transmuted into the unstable isotope Si^{31} which decays by beta emission with a 2.62 hr half-life to the stable isotope P^{31}. By mea of this reaction, donors can be produced in a silicon crystal. Because of the uniformity of flux which can be obtained in large nucl reactors, this technique lends itself to the preparation of uniforml doped n-type silicon. After irradiation the silicon crystal is heav damaged by the emitted betas, by the recoil of the decaying Si^{31}, a by the high energy neutrons that are unavoidably present in the reactor. However, this damage can be removed by annealing at temperatures near 600°C. The technique was used to produce n-type silicon with nominal resistivities between 0.1 and 20 ohm c The resistivity of the resulting crystals was uniform over dimensions of 5 cm to within ±5%.

6157 SURFACE STATES ON CLEAVED SILICON.
D.R.Palmer, S.R.Morrison and C.E.Dauenbaugh.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 170-1 (Feb. 15, 1961).

The channel conductance on Si npn and pnp junction units was measured after cleaving. No surface inversion layer was found t be present and it is concluded that the dominant surface states ar near the centre of the forbidden energy gap, in contrast to the prediction of other workers. C.A.Hoga

6158 INDIUM ANTIMONIDE.
T.S.Moss.
rogress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961)
. 189-220.

A detailed review of its preparation, band structure, optical roperties, photoeffects, electrical properties and applications. 9 refs.
J.B.Birks

6159 MAGNETORESISTANCE AND HALL EFFECT IN ORIENTED SINGLE CRYSTAL SAMPLES OF n-TYPE NDIUM ANTIMONIDE. C.H.Champness.
Canad. J. Phys., Vol. 39, No. 3, 452-67 (March, 1961).

The angular dependence of the magnetoresistance effect and the Hall effect was measured on oriented samples. The measurements were made at room temperature and liquid air temperature using a magnetic field strength of about 5000 G. Besides evidence of inhomogeneity, the results show directional dependence of the longitudinal magnetoresistance. The largest value was found in the $\langle 100\rangle$ direction. This can be explained if, in addition to electrons at the central minimum, there is some filling of the $\langle 111\rangle$ minima in k space.

6160 PRESSURE DEPENDENCE OF RESISTIVITY OF INDIUM ANTIMONIDE TO 70 000 ATMOSPHERES.
H.A.Gebbie, P.L.Smith, I.G.Austin and J.H.King.
Nature (GB), Vol. 188, 1095-6 (Dec. 24, 1960).

The effect of pressure on the melting point of InSb was studied by observing the electrical resistivity. A sudden decrease in the resistivity occurs when a sample melts because there is a trans-ition from semiconduction in the solid to metallic conduction in the liquid. The melting point was inversely proportional to pressure up to 30 000 atmospheres, and at this pressure the melting point was near 300°K. The latent heat of fusion was deduced to be 27 cal/g.
C.Hilsum

6161 SCATTERING OF ELECTRONS ON IMPURITY IONS IN LEAD TELLURIDE. T.S.Stavitskaya and L.S.Stil'bans.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2082-4 (Sept., 1960).
In Russian.

For abstract, see Abstr. 1081 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1868-70 (March, 1961)].

6162 OSCILLATORY MAGNETORESISTANCE IN N-TYPE PbTe. C.D.Kuglin, M.R.Ellett and K.F.Cuff.
Phys. Rev. Letters (USA), Vol. 6, No. 4, 177-9 (Feb. 15, 1961).

Distinct oscillations of the transverse magnetoresistance were observed in direct magnetic fields for a [110]-oriented sample of n-type PbTe having a carrier concentration of 3.45×10^{17} cm^{-3} at 1.7°K. The results confirm the predicted multi-valley band structure.
C.A.Hogarth

6163 ELECTRICAL CONDUCTIVITY OF NEAR-STOICHIOMETRIC α-Nb_2O_5.
E.H.Greener, D.H.Whitmore and M.E.Fine.
J. chem. Phys. (USA), Vol. 34, No. 3, 1017-23 (March, 1961).

The electrical conductivity of α-Nb_2O_5 monocrystalline and sintered specimens, measured under a constant ambient oxygen pressure and over the temperature range 300 to 900°C, exhibits an exponential temperature dependence with an activation energy of 1.65 eV. The isothermal conductivity, σ, of near-stoichiometric α-Nb_2O_5 is related to the ambient oxygen partial pressure, P_{O2}, by the power law expression $\sigma = \text{const } P_{O2}{}^{-0.24 \pm 0.01}$. Both sets of observations may be rationalized on the basis that slightly-reduced α-Nb_2O_5 becomes a metal-excess, n-type semiconducting oxide containing oxygen vacancies capable of trapping electrons. A detailed analysis of the relation between conductivity and ambient oxygen pressure indicated that the conductivity dependency may be ascribed to a mechanism whereby defect levels (due to oxygen ion vacancies with either one or two trapped electrons) are created and electrons are thermally excited from these levels into the conduction band.

6164 IMPACT RECOMBINATION IN Tl_2S.
J.W.Ostrowski.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 137-46. In German.

"Electron processes in solids" conference (see Abstr. 2332 of 1961). Indications are discussed that Auger processes are impor-ant in determining the lifetime of carriers produced by light in Tl_2S.
L.Pincherle

Semiconductor Devices

6165 ELECTRICAL BREAKDOWN IN GERMANIUM P–N JUNCTION. J.Yamaguchi and Y.Hamakawa.
Technol. Rep. Osaka Univ. (Japan), Vol. 9, 23-30 (March, 1959).

From experimental observations on the avalanche and turnover regions of the reverse characteristics of point contact and grown p–n junctions, it is concluded that the avalanche onset voltage increases with temperature and in the turnover region, owing to localized hot-spot formation, microplasma may occur.
G.C.Williams

6166 LOW-INERTIA GERMANIUM PHOTODIODES.
S.M.Rȳvkin, R.F.Konopleva, L.V.Mastova, O.A.Matveev, N.B.Strokan, D.V.Tarkhin and G.V.Khozov.
Fiz. tverdogo Tela. (USSR), Vol. 2, No. 9, 2199-201 (Sept., 1960).
In Russian.

For abstract, see Abstr. 20900 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1963-5 (March, 1961)].

6167 THE DEPENDENCE OF ELECTRIC BREAKDOWN OF P–N JUNCTIONS ON THE CRYSTALLOGRAPHIC DIRECTION. A.P.Shotov.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 91-5 (1959).
In Russian.

The breakdown voltages of p–n junctions in Ge were independent of the crystallographic direction. Considerations of the energy needed for collision ionization and of the effective electron mass anisotropy showed why the breakdown voltages were isotropic.
A.Tybulewicz

6168 THE TEMPERATURE DEPENDENCE OF THE BREAKDOWN VOLTAGE OF GERMANIUM AND SILICON DIODES. Zh.I.Alferov, G.V.Gordeev and V.I.Stafeev.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 104-8 (1959).
In Russian.

Derives a theoretical relationship which gives a linear rise of the breakdown voltage with increase of temperature. Reports experiments which confirm this relationship for alloyed n-type germanium and silicon diodes in the range 140-370°K for germanium and 80-500°K for silicon.
A.Tybulewicz

6169 CURRENT–VOLTAGE CHARACTERISTICS OF ALLOYED AND DIFFUSED P–N JUNCTION DIODES IN InSb. H.J.Stocker.
J. appl. Phys. (USA), Vol. 32, No. 2, 322 (Feb., 1961).

Shows curves obtained on a unit of each type at 78°K. In the alloyed unit, recombination in the depletion layer predominates over that in the bulk up to forward biases of 0.14 V and predominates throughout the forward bias range for the diffused unit. The reverse breakdown is soft at about 7 V for both units and the reverse currents are thought to be due to surface leakage effects.
F.F.Roberts

6170 DETAILED BALANCE LIMIT OF EFFICIENCY OF P–N JUNCTION SOLAR CELLS.
W.Shockley and H.J.Queisser.
J. appl. Phys. (USA), Vol. 32, No. 3, 510-19 (March, 1961).

In order to find an upper theoretical limit for the efficiency of p–n junction solar energy converters, a limiting efficiency, called the detailed balance limit of efficiency, has been calculated for an ideal case in which the only recombination mechanism of hole-electron pairs is radiative as required by the principle of detailed balance. The efficiency is also calculated for the case in which radiative recombination is only a fixed fraction f_c of the total recombination, the rest being nonradiative. Efficiencies at the matched loads have been calculated with band gap and f_c as parameters, the sun and cell being assumed to be blackbodies with temperatures of 6000° and 300°K, respectively. The maximum efficiency is found to be 30% for an energy gap of 1.1 eV and $f_c = 1$. Actual junctions do not obey the predicted current-voltage relationship, and reasons for the difference and its relevance to efficiency are discussed.

VOLTAGE–CURRENT CHARACTERISTICS OF P–N JUNCTIONS. See Abstr. 5411

RESPONSE OF SEMICONDUCTOR SURFACE-BARRIER COUNTERS TO NITROGEN IONS AND ALPHA PARTICLES. See Abstr. 5616

6171 THE COPPER STAINING OF P—N—P ALLOYED JUNCTION TRANSISTOR SECTIONS.

S.Ratcliffe and J.E.Hughes.
Brit. J. appl. Phys. Vol. 12, No. 4, 193-4 (April, 1961).

A technique is described for the staining of germanium p—n—p alloyed junction transistors using chemical deposition of copper. It is shown that copper is deposited preferentially on p-type regions and, in so doing, reveals certain features associated with regrowth processes. Other structural effects which are revealed may be connected with strain induced in the semiconductor by thermal cycling.

6172 REDUCTION OF MISALIGNMENT VOLTAGE IN HALL CRYSTALS.

C.Wood, O.Tischler and G.F.Schroeder.
Rev. sci. Instrum. (USA), Vol. 32, No. 2, 209-10 (Feb., 1961).

For the construction of Hall plates cruciform- and bar-shaped crystals were examined which enabled a misalignment voltage (V_m) as low as 10 μV to be obtained on a typical plate. On the bar-shaped crystals, slots were gradually cut near the current leads and V_m was monitored until it assumed a minimum value. C.A.Hogarth

100 dB MICROWAVE SEMICONDUCTOR SWITCH.
See Abstr. 4547

Photoconductivity

6173 KINETICS OF IMPURITY PHOTOCONDUCTIVITY AND A NEW METHOD FOR THE DETERMINATION OF THE EFFECTIVE CROSS-SECTIONS OF IMPURITY CENTRES.

E.I.Adirovič.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 115-36. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). A theoretical treatment is given for impurity photoconductivity in the case of unipolar perturbation of the semiconductor, i.e. when the non-equilibrium charge carriers are produced in the conduction band of the majority carriers only. Analytical expressions are derived for the field, current and charge distributions and the concentrations of free and bound charge carriers. For time dependent impurity photoconduction the time dependence of the potential difference across a semiconducting crystal is calculated. It is shown that experimental conditions could be chosen in such a way. that the kinetics of the photoconduction in a crystal with many different types of impurity centre are determined mainly by electron exchange between conduction band and one particular type of impurity, A new method is proposed for the determination of effective capture cross-sections for electrons and holes in impurity centres with one or several charges. This method is applicable not only to recombination levels but also to trapping levels. Some results are discussed and quantitative estimates of various parameters given. F.Ansbacher

6174 A NEW METHOD OF DETERMINING THE EFFECTIVE CROSS-SECTIONS OF LOCALIZED CENTRES.

É.I.Adirovich.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2248-51 (Sept., 1960). In Russian.

For abstract, see Abstr. 1100 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2006-8 (March, 1961)].

6175 THE VARIATION OF PHOTOCONDUCTIVITY AND INTENSITY OF LUMINESCENCE OF ANTHRACENE CRYSTALS WITH WAVELENGTH OF THE STIMULATING RADIATION.

V.V.Eremenko and V.S.Medvedev.
Fiz. tverdogo Tela (USSR) Vol. 2, No. 7, 1572-5 (July, 1960). In Russian.

An attempt to differentiate between charge carries and exciton (E) production as the mechanism for photoconduction (ϕ). Photoconduction, optical absorption (k) and luminescence (L) spectra were determined for frequencies ~ 23 000-29 000 cm^{-1}. From theoretical expressions relating ϕ or L with k and the diffusion length of the active species (assuming surface annihilation of excitons), it is concluded that ϕ is due to E production. [English translation in: Soviet Physics—Solid State (USA)]. C.H.L.Goodman

6176 THE STEADY PHOTOCONDUCTION IN THE MORE COMPLEX REACTION KINETIC MODELS.

K.W.Böer, S.Oberländer and J.Voigt.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 32-44. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). The dependence of photoconductivity in CdS on the intensity of the optical excitation is discussed. Special attention is given to the situations in which the photocurrent rises more with intensity than would be given by a linear law. P.T.Landsber

6177 THE SPECTRUM OF INFRARED QUENCHING OF PHOTOCONDUCTIVITY IN CdS—CdSe SOLID SOLUTIONS.

S.M.Rȳvkin and R.Yu.Khansevarov.
Fiz. tverdogo Tela (USSR), Sbornik [Supplement] II, 88-90 (1959). In Russian.

The wavelengths of infrared radiation which quenched the photoconductivity of a continuous series of CdS—CdSe solid solutions depended on temperature (-190° to 300°C) and on the solution composition. The temperatures at which the lux—ampere characte istics became superlinear were found to depend only slightly on the solution composition. A.Tybulewic

6178 ON THE QUESTION OF HIGH-VOLTAGE PHOTO-ELECTROMOTIVE FORCES IN THIN SEMICONDUCTO LAYERS.

V.M.Lyubin and G.A.Fedorova.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 4, 833-6 (Dec. 1, 1960). In Russian.

The spectral dependence of the photovoltage in thin layers of CdTe (thickness 1.5 μ) was examined. The rise and decay times o the voltage were found to be less than 10^{-4} sec for illumination of 100-400 lux. It was shown that the origin of the photovoltage is not associated with the illuminated electrode. In some of the specimen the photovoltage changed sign over part of the range examined. Th chalcogenides of antimony and bismuth were also examined and tab of photovoltages and dark resistivity values given. K.N.R.Taylo

6179 NEGATIVE PHOTOEFFECT IN THE LONG-WAVELENGTH ABSORPTION REGION OF CUPROUS OXIDE

E.Klier.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 199-207. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). Under suitable conditions a negative photoconductivity effe due to carrier deficiency is observable in the range 635-1100 mμ which is explained by a recombination mechanism. This also ties up with other observations on conductivity. The importance of anion vacancies for this process is stressed. The effects of the wavelength of the excitation radiation, the temperature, oxygen concentration and pre-treatment of samples is described. F.Ansbach

6180 THE EFFECT OF OXYGEN ADSORPTION ON PHOTO-AND SEMICONDUCTION OF β-CAROTENE.

B.Rosenberg.
J. chem. Phys. (USA), Vol. 34, No. 3, 812-19 (March, 1961).

The presence of adsorbed oxygen gas increases the magnitude of the surface semiconduction currents in crystalline powder β-carotene by a factor of about 10^3. The activation energy for the surface semiconduction process is 1.52 eV in argon gas and is decreased to 1.29 eV in oxygen. The room temperature photocurren is increased by a factor of about 25 in oxygen over the value in argon. The activation energy of the photoconduction process is no affected by oxygen. The increase in dark current in an oxygen ambient requires a time of about 2 hr to come to the equilibrium value at room temperature. Radiation is not required to cause the increase. The effect of the oxygen can be reversed completely by heating the β-carotene to 120° C in an inert atmosphere (dry nitrogen or argon). The increase in dark current is linearly proportional to the partial pressure of oxygen in the chamber. The rate desorption of the oxygen increases with the temperature. The resulting data yield an activation energy of desorption of 0.17 eV. It is suggested that this is the binding energy for the formation of an oxygen—carotene complex, and that the decrease in semiconductio activation energy is correlated to this binding energy. An analysi is given which leads to the conclusion that the mechanism of the current increase with formation of the oxygen complex is twofold; a decrease in the activation energy for semiconduction, and an increase in the mobility of the charge carriers. There is no eviden for a change in the charge creation process. The experimental results are considered to be a partial verification of Platt's theor on the donor—carotene—acceptor complex in photosynthesis since the triplet level of chlorophyll-b has a value of 1.43 eV, midway between the value of 1.52 eV for the free carotene semiconduction activation energy and 1.29 eV for the corresponding value of the oxygen—carotene complex. It is also suggested that a possible mechanism for the carotene protection of cells from destructive photo-oxidation may be the formation of the oxygen—carotene complex.

6181 PHOTOVOLTAGES IN SILICON AND GERMANIUM LAYERS. H.Kallmann, B.Kramer, E.Haidemenakis, W.J.McAleer, H.Barkemeyer and P.I.Pollak.
J. Electrochem. Soc. (USA), Vol. 108, No. 3, 247-51 (March, 1961).

Photovoltages up to a few hundred volts at room temperature and up to a few thousand at liquid nitrogen temperatures were observed under strong illumination in silicon and germanium layers with a distance of about 1 cm between electrodes. Only samples with a thickness gradient of evaporated material exhibited these photovoltages. In both the Ge and the Si layers the photovoltage showed an almost linear relationship with illuminating intensity. Both the magnitude and sign of the voltage depended on which side of the film was irradiated, the wavelength of incident light, and the temperature. The dark resistance of these layers varied between 10^{11} and 10^{14} ohms. A theoretical interpretation of the origin of these voltages is given.

6182 INFRARED ENHANCEMENT AND QUENCHING OF PHOTOCONDUCTION IN SINGLE CRYSTALS OF ZnS:Cu. F.G.Ullman and J.J.Dropkin.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 154-9 (Feb., 1961).

An ohmic photoconductivity peaking at 0.65 and 1.35 μ was observed at room temperature in synthetic single crystals. The photocurrents are constant with time, not dependent on any previous excitation, and linear with intensity. With simultaneous 3650 A u.v. and i.r., the resultant photocurrents are less than the sum of the separate u.v. and i.r. photocurrents as measured independently. The spectral dependence of this so-called "quenching" and also of the i.r. absorption are similar to that of the i.r. photoconductivity (as well as to quenching and stimulation spectra reported for ZnS:Cu power phosphors elsewhere). If each of these is assumed to arise from the same transition, the quenching phenomenon can be interpreted to be an electron-carrier u.v. photocurrent quenched by a hole-carrier i.r. photocurrent as in a Schoen—Klasens model. Both the i.r. photocurrent and the i.r. quenching decrease sharply at low temperatures and apparently require thermal activation.

Thermoelectric Properties

6183 THE CONDUCTIVITY OF OXIDE CATHODES. IX. THERMO-ELECTRIC POWER. G.H.Metson and M.F.Holmes.
Proc. Instn Elect. Engrs (GB), Monogr. 397E, publ. Sept., 1960 (Vol. 108C, 83-92).

Republication of the monograph already published as Abstr. 13641 of 1960.

6184 MEASUREMENT OF THE THERMOELECTRIC POWER OF LEAD SULPHIDE. A.A.Arafa, I.S.Shafie and F.S.A.Sultan.
Z. angew. Math. Phys., Vol. 7, No. 3, 256-64 (June 25, 1956).

Natural specimens of lead sulphide crystals were studied between room temperature and 700° K. Specimens which are of the n-type remain as such throughout the temperature range. The p-type specimens, however, show an initial small rise followed by a gradual decrease and a subsequent change of sign at a temperature which, in some specimens, is well defined. Further increase of temperature results in a negative extremum. From this stage onwards there seems to develop a common behaviour for both types of specimen. Some crystals which were initially of the p-type changed over to the n-type and remained as such throughout subsequent investigation. Among the crystals,one showed a metallic conduction and an extraordinary large thermoelectric power.

6185 THERMOELECTRIC POWER OF SILVER HALIDES. R.W.Christy.
J. chem. Phys. (USA), Vol. 34, No. 4, 1148-55 (April, 1961).

Thermoelectric power measurements were made on the systems $AgCl + CdCl_2$, $AgBr + Ag_2S$, and AgBr + CdS, as well as the pure silver halides, in the temperature range from 100° to 400° C. Silver metal electrodes were used. The behaviour of AgCl and $CdCl_2$ is similar to the previously investigated $AgBr + CdBr_2$ system, except that the effect of the impurity is more pronounced in AgCl. The results of Cd doping of AgBr and AgCl are analyzed according to the theory of Howard and Lidiard to give the concentration of Frenkel defects, the ratio of mobilities, and the quantities $q_i^* + q_v^*$, $q_i^* + Ts_i'$, and $q_v^* + Ts_v'$, where q* and s' are the heats of transport and entropies of formation for the interstitials and vacancies. The results are in agreement with conductivity data, but the heats of transport are surprisingly large and temperature dependent. It is concluded that association between Cd^{++} and Ag^+ vacancies is negligible above 100°C, but that association between S^{--} and Ag^+ interstitials, and between Cd^{++} and S^{--}, is significant even at 400° C.

6186 THERMOELECTRIC AND CRYSTALLOGRAPHIC PROPERTIES OF Ag_2Se. J.B.Conn and R.C.Taylor.
J. Electrochem. Soc. (USA), Vol. 107, No. 12, 977-82 (Dec., 1960).

Silver selenide was prepared by fusion techniques and found to be a good thermoelectric material. The Seebeck coefficient, resistivity, and thermal conductivity were measured as a function of temperature. The effect of doping with 30 different elements and compounds at different doping concentrations was studied. The inter-relationships between the thermoelectric properties were examined and are discussed. The crystal lattice of silver selenide was determined, and the subcell and superstructure are elucidated.

THERMOELECTRIC POWER OF DILUTE LEAD ALLOYS AT LOW TEMPERATURE: ROLE OF PHONON DRAG.
See Abstr. 6070

Dielectric Properties

6187 THE MIGRATION OF SILVER ON THE SURFACE OF CERAMIC DIELECTRICS. I.E.Balygin.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 8, 1723-8 (Aug., 1960).
In Russian.

This was investigated together with the diffusion of the electrode material into the body of the ceramic on porcelain and carborundum mullite samples subjected to d.c. stress at 400° C. Photographic evidence taken at intervals during the tests, some of which lasted up to approximately 115 hr, is presented. [English translation in: Soviet Physics—Solid State (USA)]. E.M.Dembinski

VACUUM DEPOSITION OF DIELECTRIC FILMS FOR CAPACITORS. See Abstr. 6562

6188 DIELECTRIC PROPERTIES OF SOLIDS IN RELATION TO IMPERFECTIONS. J.Volger.
Progress in semiconductors. Vol. 4, (see Abstr. 5007 of 1961) p. 205-36.

Dielectric relaxation phenomena in solids connected with structural imperfections are divided into two categories: those where the charges move over macroscopic distances, so that time conduction is present in limited regions, and those where the charges are bound to stay near an attracting centre. Each category is sub-divided, dependent on whether the moving charges are electrons or ions. Examples of each type of behaviour are discussed. The final section considers microwave experiments and inertial effects of conduction electrons. 110 refs. J.B.Birks

6189 DIELECTRIC RELAXATION DUE TO IMPURITY—VACANCY COMPLEXES IN NaCl CRYSTALS. R.W.Dreyfus.
Phys. Rev. (USA), Vol. 121, No. 6, 1675-87 (March 15, 1961).

Sodium-ion vacancies were introduced into sodium chloride crystals by the addition of the following divalent cation impurities: Mg^{2+}, Mn^{2+}, Ca^{2+}, Zn^{2+}, Cd^{2+}, and Sr^{2+}. Below 150°C, the virtual negative charge of a cation vacancy binds the majority of the vacancies to the divalent impurity ions to form complexes. The reorientation of these dipolar complexes was observed in the present experiments as a transient dielectric polarization current occurring immediately after the application of a d.c. electric field. Below 0°C, the dominant effect is an exponential "fast polarization" due to complexes in which the vacancy is in the nearest sodium-ion site to the impurity ion (except for the case of $NaCl:Mg^{2+}$). Also observed is a "very fast polarization" which may be interpreted as due to next-nearest-neighbour impurity—vancancy complexes, plus a "slow polarization" ascribed to vacancies jumping between more distant bound sites. By combining the present measurements with earlier a.c. measurements, one can obtain particularly accurate values for the jump activation energies of vacancies occupying the nearest-neighbour site to Ca^{2+} and Mn^{2+} ions in a NaCl crystal.

The energies obtained for these two cases are 0.702 ± 0.010 and 0.680 ± 0.010 eV, respectively. From the manner in which the relaxation time at a given temperature varies with the radius of the impurity ion, the dominant jump mechanisms can be inferred. The major reason for the decrease in relaxation time with decreasing radius of the impurity ion appears to be the strong dependence of the jump rate of the impurity ion on ionic radius.

6190 INFLUENCE OF DISTURBANCE OF THE PERIODICITY OF THE CRYSTAL LATTICE BY A CHARGE ON DIELECTRIC LOSS IN THE SUPER HIGH FREQUENCY REGION.

V.S.Vinogradov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 10, 2622-8 (Oct., 1960). In Russian.

A theoretical paper in which an expression is obtained for the imaginary component of the dielectric constant by considering the potential energy of the lattice and the effect of impurity charges on the dipole moment. [English translation in: Soviet Physics—Solid State (USA)]. R.F.S.Hearmon

6191 DIELECTRIC CONSTANTS OF CRYSTALLINE POWDERS AT MICROWAVE FREQUENCIES.

B.P.Pradhan and R.C.Gupta.
J. sci. industr. Res. (India), Vol. 19B, No. 7, 229-32 (July, 1960).

Dielectric constants of alkali-halide crystals were measured in the 10 cm microwave region by the standing-wave technique using the method of mixtures. Ionic polarization was determined for the crystals and from it Szigeti's short-range correction factor S was calculated. A good agreement was observed between Szigeti's and the authors' values for the correction factor S. The dielectric constants of sodium halides are greater than those of potassium halides and the dielectric constants of all these halides show a regularly increasing trend from chloride via bromide to iodide. This behaviour is explained in terms of the ionic polarization of these crystals.

6192 THE PHOTODIELECTRIC EFFECT IN ZnS:Cu:Co PHOSPHORS. F.I.Vergunas and G.M.Malkin.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2322-9 (Sept., 1960). In Russian.

For abstract, see Abstr. 1129 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2071-6 (March, 1961)].

6193 SOME REMARKS ON SECOND ORDER PHASE TRANSITIONS AND THE MICROSCOPIC THEORY OF FERROELECTRICS. V.L.Ginzburg.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2031-43 (Sept., 1960). In Russian.

The characteristics of different second order transitions (superconductors, liquid helium, ferromagnetics, ferroelectrics etc.), are explained on the basis of various relations between volume and correlation energies. The microscopic theory of ferroelectrics is considered in terms of a comparison between the anharmonic oscillator model and the vibrating crystalline lattice model. The behaviour of optical vibration frequencies near the transition point is clarified. [English translation in: Soviet Physics—Solid State (USA)]. R.F.S.Hearmon

6194 THE ELECTRICAL CONDUCTIVITY OF A SINGLE CRYSTAL OF TRIGLYCINE SULPHATE.

V.M.Gurevich, I.S.Zheludev and I.S.Rez.
Kristallografiya (USSR), Vol. 5, No. 1, 142-5 (Jan.-Feb., 1960). In Russian. English translation in: Soviet Physics—Crystallography (USA), Vol. 5, No. 1, 133-5 (July-Aug., 1960).

The d.c. resistance of single-crystal triglycine sulphate was measured along the crystallographic axes XYZ over the temperature range 20-40° C. Conduction transients were observed with the Y-cut crystals at temperatures below the phase-transition point (49° C), and these were associated with the existence of the ferroelectric phase. Assuming ionic conduction, the carrier activation energy was found to be dependent upon the phase (ferro- or paraelectric), and the crystallographic direction. P.A.Walker

6195 FERROELECTRICS WITH DIFFUSE PHASE TRANSITIONS.

G.A.Smolenskii, V.A.Isupov, A.I.Agranovskaya and S.N.Popov.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 11, 2906-18 (Nov., 1960). In Russian.

Polycrystalline samples of $\mathrm{Pb(Mg_{1\ 3}Nb_{2\ 3})O_3}$—$\mathrm{Pb(Ni_{1\ 3}Nb_{2\ 3})O_3}$ and $\mathrm{Ba(Nb, Ta)_2O_6}$—$\mathrm{Sr(Nb, Ta)_2O_6}$ had diffuse phase transitions due to composition fluctuations (random distribution of cations in their sublattice). Relaxation polarization in the phase-transition region was due to motion of the boundary between stable and metastable domains. [English translation in: Soviet Physics—Solid State (USA A.Tybulewi

6196 FERROELECTRIC AND ANTIFERROELECTRIC ARRANGEMENTS IN PEROVSKITE-TYPE SUBSTANC

A.Jaśkiewicz and H.Konwent.
Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vol. No. 10, 699-702 (1960).

Criteria for the stability of various modes of ordering of the B-ion displacements in an $\mathrm{ABO_3}$ perovskite structure are discusse It is assumed that the B-ions form thermal dipoles whilst the A- an O-ions polarize elastically; only the nearest-neighbour electrostat interactions are considered. L.E.Cro

6197 SOME FEATURES OF THE PIEZOELECTRIC EFFEC IN BARIUM TITANATE. Z.A.Shamro.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2085-8 (Sept., 1960). In Russian.

For abstract, see Abstr. 2433 of 1961. [English translation in Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1871-3 (March, 1961)].

6198 CHARACTERISTIC CURVES OF A PYRAMID TYPE O ELECTRET. C.S.Bhatnagar.

J. sci. industr. Res. (India), Vol. 19B, No. 8, 277-81 (Aug., 1960).

The voltage—current characteristics of a pyramid-shaped electret, formed from carnauba wax and having five flat surfaces, four of which were the sides and the fifth was the base, were investigated; a potential of 300 V d.c. was applied across two opposite sides to form the electret. The characteristics obtained for different terminal combinations showed that rectification was maximum in the polarized direction. In the case of a given pair of terminals rectification increased with the application of negativ potential to the remaining terminals on other faces. The characte istics were similar to those of a radio valve.

6199 INORGANIC ELECTRETS. A.Gubkin and G.I.Skanavi.

Fiz. tverdogo Tela (USSR), Vol. 3, No. 1, 297-304 (Jan., 1961). In Russian.

A brief review of recent work on electrets made of polycrystalline inorganic (ceramic) dielectrics. Deals with the stabil polarization (10^{-6}-10^{-5} C/cm^2 produced by fields of 2 and 20 kV/c without heating or illumination), piezoelectric properties and the mechanism of formation of the electret state in materials such as $\mathrm{MgTiO_3}$, $\mathrm{ZnTiO_3}$, $\mathrm{BaO.4TiO_2}$, $\mathrm{Bi_2O_3.2TiO_2}$, $\mathrm{CaTiO_3}$, $\mathrm{SrTiO_3}$, $\mathrm{SrTiO_3}$–$\mathrm{BiTiO_3}$, $\mathrm{BaTiO_3}$, etc. (both ferroelectric and non-ferroelectric). [English translation in: Soviet Physics — Solid State (USA)]. A.Tybulew

OPTICAL PROPERTIES OF SOLIDS

(Including X-ray Spectra)

6200 SOME OPTICAL PROPERTIES OF POWDER AND CRYSTAL HALOPHOSPHATE PHOSPHORS.

P.D.Johnson.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 159-62 (Feb., 1961).

Diffuse reflectivity and excitation spectra of powder and opti absorption of synthetic single crystal halophosphate phosphors we determined in the spectral region 1100-3000 A. Intrinsic optical absorption by the host lattice begins at approximately 1500A in fluoroapatite and 1570 A in chloroapatite. Absorption in bands of manganese in fluoroapatite at 1600, 1750, and 2150 A results in luminescence in the absence of antimony. Absorption due to antimony lies between 1600 and 2900 A. The preparation and some optical properties of synthetic single crystals are described.

6201 OPTICAL CONSTANTS OF MASSIVE METALS. M.Otter.

Z. Phys. (Germany), Vol. 161, No. 2, 163-78 (1961). In German.

The optical constants are obtained by Drude's method for copper, silver and gold in the form of hemispherical single cryst The crystal surfaces are untouched in preparation, no polishing i carried out and surfaces are very clean. The characteristics in lattice and free electron absorption regions differ in a specific w from earlier data. The surfaces have a smaller resistance than that found for evaporated or polished metal layers. A theoretical discussion is included. G.F.J.Garlick

6202 OPTICAL PROPERTIES OF CdS MONOCRYSTALS.
M.S.Brodin.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2152-7 (Sept., 1960). In Russian.

For abstract, see Abstr. 2437 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1926-30 (March, 1961)].

6203 MAGNETO-OPTICAL PHENOMENA IN SEMICONDUCTORS.
B.Lax and S.Zwerdling.

Progress in semiconductors. Vol. 5 (see Abstr. 5008 of 1961) p. 221-72.

The phenomena discussed in this review include magneto-absorption, the Zeeman effect of excitons in cuprous oxide and germanium, magneto-absorption of impurities, the Faraday effect in InSb, Ge and Si and magneto-plasma effects. The experimental techniques used in the study of magneto-absorption and the Zeeman and Faraday effects are described. 82 refs. J.B.Birks

6204 OBLIQUE REFLECTANCE AND TRANSMITTANCE MEASUREMENTS ON ALUMINIUM FILMS.
T.Turbadar.

Vacuum (GB), Vol. 9, 139-43 (May, 1959; publ. Dec., 1960).

Reflectances and transmittances of thin aluminium films deposited on glass were measured as a function of the angle of incidence and the state of polarization of the incident light. The experimental results were compared with theoretical predictions. The oxide layer which forms on the Al film as this is exposed to air was taken into account and discussed. Experimental results indicate that the refractive index of an Al film thicker than 80 A is independent of thickness.

6205 THE INFRARED ABSORPTION AND THE ENERGY-BAND STRUCTURE OF CUPROUS OXIDE.
M.P.Lisitsa and G.A.Kholodar'.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2117-25 (Sept., 1960). In Russian.

For abstract, see Abstr. 2446 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1897-1903 (March, 1961)].

6206 EFFECT OF PRESSURE ON THE SPECTRA OF FIVE NICKEL COMPLEXES.
D.R.Stephens and H.G.Drickamer.

J. chem. Phys. (USA), Vol. 34, No. 3, 937-40 (March, 1961).

The effect of pressure to 150 kbars was measured on the absorption spectra of five nickel complexes. The results are discussed in terms of the change of 10 Dq and of the Racah parameter B, with pressure. In general 10 Dq, the crystal field strength, increased with pressure, but the increase noted was not the same when calculated for the different peaks of a given complex. This discrepancy may be described in terms of changes of covalency as measured by changes of the Racah parameter B. In general B decreased with increasing pressure showing increased covalency at high pressure. There were some discrepancies in the value of B obtained from different transitions. These may be the result of experimental error, but may also be associated with distortions of the field, or with weaknesses in the assumption of point charges or dipoles.

6207 ZEEMAN EFFECT OF THE Sm^{+++} $^6H_{5/2} \rightarrow {}^6F_{11/2}$ TRANSITION IN HEXAGONAL $Sm(C_2H_5SO_4)_3.9H_2O$.
H.Lämmermann.

Z. Phys. (Germany), Vol. 160, No. 4, 355-62 (1960). In German.

The absorption spectrum of this group of lines near 10 500 cm^{-1} was recorded photographically at liquid He and liquid-air temperatures. The Zeeman splitting leads to a g-factor for the excited state of 1.44, as expected for Russell—Saunders coupling. The matrix elements of the crystal field are determined. G.F.Lothian

6208 OPTICAL AND INFRARED SPECTRA OF THE FERRITES AND GARNETS.
K.A.Wickersheim.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 205S-212S (March, 1961).

A discussion of the variety of applications of spectroscopy to the study of magnetic materials (as restricted to the ferrites and garnets) is presented. Far infrared atomic spectra, infrared vibration spectra, and impurity spectra are discussed as well as the visible and near-visible spectra of the transition-metal and rare-earth ions. The optical study of the iron–rare earth exchange interaction in the garnets is described in some detail.

6209 ANALYSIS OF THE ABSORPTION SPECTRUM AND ZEEMAN EFFECT OF THULIUM ETHYLSULPHATE.
E.Y.Wong and I.Richman.

J. chem. Phys. (USA), Vol. 34, No. 4, 1182-5 (April, 1961).

The crystalline field interaction was calculated using first-order perturbation theory on intermediate coupling wave-functions of Tm^{3+} in a D_{3h} field. Good agreement with experimental data of Tm^{3+} diluted with $La(C_2H_5SO_4)_3 \cdot 9H_2O$ was obtained. The following crystalline field parameters were chosen for best fit: $A_2^0 \langle r^2 \rangle = 129.8\ cm^{-1}$, $A_4^0 \langle r^4 \rangle = -71.0\ cm^{-1}$, $A_6^0 \langle r^6 \rangle = -28.6\ cm^{-1}$, $A_6^0 \langle r^6 \rangle = 432.8\ cm^{-1}$.

OPTICAL ABSORPTION BY TETRACENE MICROCRYSTALS: EVIDENCE FOR THE EXISTENCE OF SURFACE EXCITONS.
See Abstr. 6090

6210 THE ABSORPTION EDGE SPECTRUM OF SEMICONDUCTORS.
T.P.McLean.

Progress in semiconductors, Vol. 5, (see Abstr. 5008 of 1961) p. 53-102.

Measurements of the absorption edge in germanium and silicon, using infrared diffraction gratings which increased the resolving power by an order of magnitude, revealed a wealth of detailed structure which, when analysed, yields much information about these substances. The theory of direct and indirect transitions is presented, and the experimental methods are described. The experimental data on germanium and silicon are presented and interpreted in terms of band structure, excitons and phonons. 72 refs. J.B.Birks

6211 ACTIVATION OF SINGLE PHONON INFRARED LATTICE ABSORPTION IN NEUTRON IRRADIATED DIAMOND.
S.D.Smith and J.R.Hardy.

Phil. Mag. (GB) (Eighth Ser.), Vol. 5, 1311-14 (Dec., 1960).

By giving the type IIa diamond a fast-neutron dose of $3 \times 10^{17}\ cm^{-2}$, the authors succeeded in activating a band in the absorption spectrum. The spectrum showed strong continuous absorption, commencing sharply at the Raman energy and extending to lower frequencies, which can only be explained satisfactorily as single-phonon lattice absorption. The continuous absorption produced by damage appears to be too strong to be activated solely by isolated point defects and it is suggested, therefore, that most of the damage-induced activation arise from regions of local disorder which probably involve more than 10^{20} atoms. R.Bullough

6212 THE OPTICAL ABSORPTION OF GALLIUM ARSENIDE IN THE RESTRAHLEN BAND.
S.J.Fray, F.A.Johnson, J.E.Quarrington and N.Williams.

Proc. Phys. Soc. (GB), Vol. 77, Pt 1, 215-17 (Jan., 1961).

Several lattice absorption bands are observed between 30 and 40 μ. One band is due to the emission of a single longitudinal optical phonon, and two others to transverse optical phonons. Part of the spectrum depends on the shape, size and orientation of the sample. C.Hilsum

6213 INFRARED SPECTRA OF SOLID HYDROCARBONS AT VERY LOW TEMPERATURES.
J.J.Comeford and J.H.Gould.

J. molecular Spectrosc. (USA), Vol. 5, No. 6, 474-81 (Dec., 1960).

Mixtures of various hydrocarbons with argon were condensed on a CsI window cooled with liquid helium or hydrogen and the absorption spectra recorded in the region 700-3500 cm^{-1}.

6214 INFRARED SPECTRUM OF SINGLE CRYSTALS OF LiOH, LiOD, AND LiOH·LiOD.
R.M.Hexter.

J. chem. Phys. (USA), Vol. 34, No. 3, 941-7 (March, 1961).

High-resolution infrared absorption spectra of single crystals of LiOD and of the solid solution LiOH·LiOD are reported. These are compared with each other and with the spectrum of monocrystalline LiOH. Comparisons with the spectra of $Mg(OH)_2$ and $Ca(OH)_2$ are also made. The differences in selection rules for the two types of hydroxides are discussed together with differences in spectra to be expected upon changing the mass of the cation and upon deuterium substitution. The discussion is in terms of the current theory of the spectra of such crystals. It is concluded that the complex spectrum of these minerals in the high-frequency region (2000-5000 cm^{-1}) is entirely due to OH^- (or OD^-) ion motion.

The motion is quite localized; the motions of the several OH^- ions of the crystal are poorly coupled. Difficulties with previous assignments due to unusual temperature dependencies of intensities are also discussed. The restricted rotational character of the localized motion of the OH^- ions, previously proposed, may be used to rationalize these difficulties and to qualitatively account for the existence and similarity of the spectra of all three materials. Finally, the "rotational" model accounts well for the frequency shifts consequent on deuteration.

6215 INFRARED PROPERTIES OF FLAME-FUSED MnO CRYSTALS. E.Loh and R.Newman.

J. appl. Phys. (USA), Vol. 32, No. 3, 470-4 (March, 1961).

Flame-fused MnO single crystals show continuous "absorption" in the near-infrared region and absorption peaks near 0.1 eV, both strongly dependent on the excess oxygen content in the crystal. Evidence indicates that a precipitated phase, probably Mn_3O_4, is responsible for the scattering and absorption. Hydrogen treatment converts the MnO crystal from p to n type as measured thermoelectrically. The optical and mechanical properties of the MnO are altered by hydrogen treatment.

6216 INVESTIGATIONS OF THE STRUCTURE OF THE BREMSSTRAHLUNG-ISOCHROMATS OF W, Mo AND Ta. R.Sandström.

Ark. Fys. (Sweden), Vol. 18, Paper 19, 305-27 (1960).

The structure near the short-wavelength limit of the continuous X-ray spectrum was investigated, using a concave crystal spectrometer with a Geiger counter. The isochromats found (for W, Mo and Ta at ~ 3.7 kV) are interpreted by comparisons with characteristic energy loss spectra and X-ray absorption spectra. Angular and voltage dependence of the structure are discussed. A new method of determining $V\lambda_s(h/e)$ with great accuracy is demonstrated. A new procedure for precision measurement of high voltages (accuracy 2 : 100 000) was developed.

6217 ON THE STRUCTURE NEAR THE SHORT WAVE-LENGTH LIMIT OF THE CONTINUOUS X-RAY SPECTRUM. P.Johansson.

Ark. Fys. (Sweden), Vol. 18, Paper 20, 329-38 (1960).

Using a curved crystal spectrometer with good vacuum properties and cooled targets, the structure near the quantum limit of the continuous X-ray spectrum was studied by the isochromat method. The isochromats of W, Ni, Cr (metals) and Cr_2O_3 (semiconductor) were recorded at 5.4 kV. The W curve resolution was improved and for Ni, Cr and Cr_2O_3 a foot structure near the limit observed. A shift of 1.5 V of the limit of Cr_2O_3 as compared to that of metallic Cr is reported. The fine structure and the shift support a certain interpretation of the structure, which is derived from consideration of the characteristic energy losses of the primary electrons and the density of states of the target material.

6218 INVESTIGATION OF THE FINE STRUCTURE OF THE X-RAY K-ABSORPTION EDGES OF MANGANESE IN MnTe IN THE RANGE OF TEMPERATURES OF THE ANTIFERROMAGNETIC TRANSFORMATION.

É.E.Vainshtein, B.I.Kotlyar and R.M.Ovrutskaya.

Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 133-5 (Jan. 1, 1961). In Russian.

The K X-ray absorption spectrum of MnTe was determined over the range of temperatures 8°C to 50°C, which extends on both sides of the Néel point at 37°C. The focusing method of Johann was used. Fine-structure absorption curves obtained at five temperatures in the above range are shown. Their features are discussed and conclusions concerning the origin of the lines and their connection with the structure of the material are drawn. N.Davy

6219 CALCULATION OF X-RAY INTENSITIES FROM ELECTRON PROBE SPECIMENS. L.S.Birks.

J. appl. Phys. (USA), Vol. 32, No. 3, 387-90 (March, 1961).

Complete calibration curves may be prepared for electron probe specimens of any matrix composition without the aid of known calibration standards. When there is no fluorescent excitation of the desired element by matrix components, the equation for relative X-ray intensity is simply $I_A/I_{100} = F_A W_A / F_{A_{100}}$, where I_A and I_{100} are the intensities from weight fraction W_A and from 100% of the element, respectively; F_A and $F_{A_{100}}$ are values of an "intensity variable" at W_A and 100% of the desired element. Values of F for all elements from Ti to Au (and probably from Al to Ti as well) for any take-off angle Ψ, and for any matrix composition, can be obtained from a single intensity-variable curve that will be valid for any electron probe instrument operated in the 25-30 keV range. When there is fluorescent excitation of the desired element A by characteristic radiation from matrix element B, the equation is the same except for a fluorescent correction term K_F, which is evaluated from tabulated values of absorption coefficients and excitation efficiencies. Then $I_A/I_{100} = F_A W_A(1 + K_F)/F_{A_{100}}$. For the NRL electron probe operated in the 25-30 keV range, X-ray intensities calculated from these equations agreed with measured values to within 5% of the amount present even when very strong fluorescence by matrix elements occurred.

6220 INTERACTION CROSS-SECTION OF SOFT X-RAYS WITH LITHIUM. A.S.Ganeev and I.M.Izrailev.

Zh. tekh. Fiz. (USSR), Vol. 30, No. 9, 1085-6 (Sept., 1960). In Russian.

The authors report measurements of the absorption coefficien of X-rays from 5.5 to 20 keV in lithium. After allowing for known impurities, they discuss the contributions of photoelectric absorption and of elastic and inelastic scattering to the total cross-section. [English translation in: Soviet Physics — Technical Physics (USA), Vol. 5, No. 9, 1016-17 (March, 1961)]. A.E.I. Research Laborator

6221 EFFECT OF STRUCTURE ON THE SPECTRA EMITTED BY SOLID NITROGEN DURING ELECTRON BOMBARDMENT. L.J.Schoen and H.P.Broida.

J. molecular Spectrosc. (USA), Vol. 5, No. 5, 416-19 (Nov., 1960).

Spectra emitted from solids subjected to electron bombardmen at low temperature were found to exhibit a dependence on depositio flow rate. It is shown that the observed changes may be ascribed to the effect of deposition temperature on the structure of the solid

Luminescence

6222 TRAPS IN INORGANIC CRYSTALLINE PHOSPHORS IN THE ATOMIC CONFIGURATION COORDINATE MODE J.Buhrow.

Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 278-94. In German.

"Electron processes in solids" conference (see Abstr. 2382 o 1961). The usual equation for temperature quenching of phosphors has a term exp(-W/kT) where the activation energy W is derived from the configuration coordinates of the ground and excited states In many cases there is a rise of emission with increasing temperature before quenching sets in; this may be explained by release of electrons from traps. A formula is derived for the emission, containing one or two more exponential terms of the above form wi values of W relating to the trap depths. A plot of log I/I_0 v. $1/T$ shows two straight-line portions meeting at the temperature of maximum emission, or if two trap levels are involved, the low temperature section may show a change of slope. From such a plot the three constants and three values of W can be determined. The application of the theory to experimental results is shown for Mn-activated Cd borate, silicate, and chlorophosphate; Ce sulphate and Mg germanate; also Sm-activated $CaWO_4$. A short discussion is included. S.T.Henderso

6223 THE MAGNITUDE OF THE "REACTION KINETICS" PARAMETER. M.Schön.

Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 315-19. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). Two methods of determining the reaction kinetics paramete are given. These methods require the values of the ratios of the recombination coefficient for the luminescent activator levels to th capture cross-section for the electron in the bound state, and also the ratio of the former quantity to the coefficient for the radiative recombination of free holes with bound electrons. A.J.Fc

6224 THE SIGNIFICANCE OF THE TEMPERATURE DEPENDENCE OF FLUORESCENCE INTENSITY. C.H.Haake.

J. Electrochem. Soc. (USA), Vol. 108, No. 1, 78-82 (Jan., 1961).

For some phosphors the fluorescence intensity increases with increasing temperature, reaches a maximum, and then decreases. This behaviour arises from a competition of an increasing absorption for the exciting radiation and thermal quenching of the emitted radiation. However, the slope of the initial rise of fluorescence an the temperature of the maximum also depend rather strongly on the thickness of the sample considered. Thin samples, i.e., those i which the penetrating exciting radiation is not absorbed completely, in comparison with thick samples exhibit a steeper slope and a maximum at higher temperature. If the phosphor is in powder form, the average particle size also influences the slope and the position of the maximum although generally to a lesser degree than the sample thickness. Experimental data are presented for magnesium fluorogermanate and magnesium fluoroarsenate, both activated with manganese.

6225 LETTER TO THE EDITOR.

V.M.Agranovich.

Optika i Spektrosk. (USSR), Vol. 9, No. 6, 798 (Dec., 1960). In Russian.

In an earlier paper on migration of energy of electron excitation by means of virtual excitons (Abstr. 21011 of 1960) the author used an effective-mass approximation for excitons. This led to wrong results. A modified derivation of the transition probability is given here without the use of this approximation [English translation in: Optics and Spectrosc. (USA), Vol. 9 No. 6, 421 (Dec., 1960)]. A.Tybulewicz

A COMPARISON OF TWO FLUOROMETERS DESIGNED TO MEASURE THE RADIATION-INDUCED FLUORESCENCE OF SILVER-ACTIVATED GLASS RODS. See Abstr. 5707

6226 LEAD- AND MANGANESE-ACTIVATED CALCIUM CADMIUM SILICATE PHOSPHORS.

Y.Uehara, Y.Kobuke, I.Masuda and T.Kushida.

J. Electrochem. Soc. (USA), Vol. 108, No. 3, 235-8 (March, 1961).

The preparation and properties of (Pb + Mn) -activated calcium cadmium silicate phosphors with various mole ratios of Cd to Ca are described. All phosphors produce a main, broad and variable emission band in the orange, and three minor, narrow and invariant bands at about 6880, 6950 and 7050 A. The phosphors show a complicated shift of the main emission band with increasing Cd content, despite a linear relationship between Cd content and lattice spacings. The introduction of sulphate ions into the phosphor base changes the emission characteristics. With half of the Ca introduced as sulphate, the peak emission shifts from 6100 to 6200 A. The results are discussed in the light of several assumptions.

6227 INVESTIGATIONS ON THE LUMINESCENCE OF QUARTZ ACTIVATED BY X-RAYS.

R.T.Bayley, L.Holzapfel and J.Lehmann.

Naturwissenschaften (Germany), Vol. 47, No. 20, 464-5 (Oct., 1960). In German.

The luminescence of quartz milled to a fine powder is largely in the blue and ultraviolet, and is a maximum if fired at 900°C before irradiation by X-rays. S.T.Henderson

6228 INTRAMOLECULAR ENERGY TRANSFER IN RARE EARTH CHELATES. ROLE OF THE TRIPLET STATE.

G.A.Crosby, R.E.Whan and R.M.Alire.

J. chem. Phys. (USA), Vol. 34, No. 3, 743-8 (March, 1961).

Results of luminescence studies on chelates of La^{3+}, Sm^{3+}, Eu^{3+}, Gd^{3+}, Tb^{3+}, Dy^{3+}, Tm^{3+}, Yb^{3+}, and Lu^{3+} are reported. It is shown that the intramolecular energy transfer efficiency is a sensitive function of the relative positions of the resonance energy levels of the ions and the metastable triplet states of the complexes. In the case of Eu^{3+} it is demonstrated that, by a proper choice of ligands, it is possible to selectively excite only the lowest resonance level of the two existing resonance levels of this ion. Coupling of the rare-earth ions to the ligands is discussed, and a comparison is made between the optical properties of rare-earth ions in chelates and in inorganic salts.

6229 FLUORESCENCE OF VARIOUS MODIFICATIONS OF URANYL SULPHATE. D.N.Pande.

J. sci. industr. Res. (India), Vol. 19B, No. 2, 71-2 (Feb., 1960).

Emission spectra are shown for five modifications, most of which differ by the amount of water of crystallization. They are prepared by different crystallization and heating procedures. S.T.Henderson

6230 TRANSIENTS IN THE BLUE AND GREEN LUMINESCENCE OF ZnS:Cu:Cl CRYSTALS.

A.Halperin and H.Arbell.

J. chem. Phys. (USA), Vol. 34, No. 3, 879-83 (March, 1961).

Upon exciting the ZnS crystals by the light of two wavelengths, 0.37 and 0.33 μ, in succession, their blue luminescence at low temperatures was found to rise to a maximum I_m from which it decayed to its normal steady value I_∞. The green luminescence band showed a similar effect above 170°K. A reduction in the degree of filling of the "blue" traps was found to take place during the decay of the transients at low temperatures. Results are discussed using a previously proposed energy model.

6231 THE FREEZING OF ENERGY TRANSFER IN ORGANIC MIXED CRYSTALS.

K.Gschwendtner and H.C.Wolf.

Naturwissenschaften (Germany), Vol. 48, No. 2, 42-3 (1961). In German.

The temperature dependence of the intensity of fluorescence bands of anthracene crystals containing 0.2% tetracene, and of naphthalene crystals containing 0.02% anthracene and 2-methylnaphthalene was obtained between 4° and 90°K. In the anthracene crystals, the lattice fluorescence decreased between 20° and 45°K, in naphthalene the decrease occurred between 5° and 12°K with a corresponding increase in impurity fluorescence. The activation energies for the transfer are 15 cm^{-1} and 50 cm^{-1} for naphthalene and anthracene respectively. J.Franks

LUMINESCENCE OF ANTHRACENE. WAVELENGTH DEPENDENCE. See Abstr. 6175

6232 THE LUMINESCENCE MECHANISM OF CRYSTAL PHOSPHORS OF ZnS TYPE. R.Seiwert.

Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 64-109. In German.

"Electron processes in solids" conference (see Abstr. 2382 of 1961). A discussion of previous work, especially the author's (Abstr. 4438-9 of 1960), with a view to determining the energy levels involved in the temperature quenching of different emission bands in CdS (with and without activator impurities). Calculations based on the Schön—Klasens model, using the concentrations of holes and electrons in various levels and their transition probabilities, show that log $(I_0/I - 1)$ should be linear with respect to 1/T, as found by experiment. For the green and red bands, the calculated values of dE the energy separation of trap from conduction band or of activator level from valency band, agree reasonably with the differences between band gap and emission energy of the band in question. For two orange bands the difference is about twice the calculated dE, an explanation being that the luminescent transition is between a trap and an activator level which are about equidistant from the upper and lower edges respectively of the forbidden gap. Numerical values of other constants suggest that the green and orange bands arise from transitions from conduction band to activator level, not from trap to valency band. With rise of temperature over a certain range, the red emission increases. The trap depths concerned are calculated for a given excitation density and different recombination coefficients. A discussion is reported. S.T.Henderson

6233 RELAXATION SPECTRUM OF KYANITE.

N.A.Tolstoi and Lyu Shun'-fu [Liu Shun-fu].

Optika i Spektrosk. (USSR), Vol. 9, No. 6, 787-90 (Dec., 1960). In Russian.

Reports and discusses luminescence and relaxation (dependence of the decay constant on wavelength) spectra of kyanite (Al_2SiO_5.Cr) at -180° and 20°C. [English translation in: Optics and Spectrosc. (USA), Vol. 9, No. 6, 415-16 (Dec., 1960)]. A.Tybulewicz

6234 PARAMAGNETIC RESONANCE ABSORPTION IN NAPHTHALENE IN ITS PHOSPHORESCENT STATE.

C.A.Hutchison, Jr and B.W.Mangum.

J. chem. Phys. (USA), Vol. 34, No. 3, 908-22 (March, 1961).

Paramagnetic resonance absorption was observed in naphthalene solid solution in a single crystal of durene when irradiated with light from a mercury lamp. The fine structure of the spectrum at a frequency of ~22.7 × 10^9 c/s may be described by the spin-Hamiltonian

$$\mathcal{H} = |\beta|\ H\cdot g\cdot S + DS_z^2 + E(S_x^2 - S_y^2),$$

with

$$S = 1,$$
$$g = 2.0030 \pm 0.0004 \text{ (isotropic)},$$
$$D/hc = \pm 0.1003 \pm 0.0006 \text{ cm}^{-1},$$
$$E/hc = \mp 0.0137 \pm 0.0002 \text{ cm}^{-1}.$$

Observations at a different frequency, ~9.7 × 10^9 c/s, and also measurements on perdeuteronaphthalene are described by essentially the same parameters. The fine structure data identify the spectrum as arising from a triplet state and leave no doubt as to the triplet character of the phosphorescent state of naphthalene. The zero-field splitting of the triplet has its origin in the magnetic dipole—dipole interaction between the two unpaired electrons in the triplet state. These experimental results are in agreement with the theoretical estimates. Hyperfine structure was observed and is interpretable on the basis of the anisotropic hyperfine interaction constants for a C—H fragment given by McConnell. The π-electron spin density on the α-carbons is found to be 0.209. The hyperfine structure results identify the spectrum as arising from naphthalene. In addition they show that the triplet state is $^3B_{2u}{}^+$ and that the naphthalene molecules are oriented in the crystals such that they are not only coplanar with the durene molecule which they replace but also have their long and short twofold axes in this plane parallel, respectively, to the long and short axes of durenes.

6235

ON THE ANTI-STOKES PHOSPHORESCENCE OF ORGANIC SUBSTANCES.

V.A.Pilipovich.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 754-8 (Dec., 1960).
In Russian.

The decay laws and the degree of polarization of afterglow of trypaflavine, acridine orange, esculin, and auramine, were studied. They were excited with light of various wavelengths including the anti-Stokes region. The decay of phosphorescence at room temperature was faster in the anti-Stokes region, but the degree of polarization was unaffected. [English translation in: Optics and Spectrosc. (USA), Vol. 9, No. 6, 396-8 (Dec., 1960)]. A.Tybulewicz

6236

EFFECT OF SOLVENT AND SOLUTE STRUCTURE ON SCINTILLATOR PULSE HEIGHTS. I. CORRELATION OF PULSE HEIGHTS FOR RING SUBSTITUTED STYRENE PLASTIC SCINTILLATORS WITH HAMMETT SUBSTITUENT CONSTANTS.

S.R.Sandler and S.Loshaek.
J. chem. Phys. (USA), Vol. 34, No. 2, 439-44 (Feb., 1961).

A group of different ring substituted styrene plastic scintillators was prepared with a constant concentration of p-terphenyl as the fluor and POPOP as the waveshifter. The effect of this variation in the structure of the polymer phase on pulse-height response to β and γ radiation was determined. It was found that correlations exist between the relative pulse height and the Hammett (σ) and Taft (σ_I) substituent constants for the substituted polystyrenes. Pulse heights increase with an increase in the negative value of the substituent constant, i.e. with an increase in the electron-donating power of the ring substituent on the polystyrene. It was found that markedly lower relative pulse heights were obtained for a series of styrene plastics in which the α-hydrogen in the backbone chain was substituted by a methyl group. This suggests than an α-hydrogen in the backbone chain is required for an efficient plastic solvent.

6237

PHOSPHOR EFFICIENCY AT VERY LOW EXCITATION CURRENT DENSITIES.

G.W.Francis and R.G.Stoudenheimer.
Rev. sci. Instrum. (USA), Vol. 31, No. 11, 1246-7 (Nov., 1960).

As the stationary current density on ZnS:Ag screens decreases over a certain range, the luminescence efficiency falls by about one half whether the applied voltage is 10, 12.5 or 15 kV. At 15 kV and above 10^{-10} A/cm^2 the efficiency is steady at 7.4 lm/W, and below 4×10^{-13} A/cm^2 it is steady at 4.0 lm/W. S.T.Henderson

6238

THE INTENSITY OF THE SLOWLY DECAYING COMPONENT OF STILBENE LUMINESCENCE EXCITED WITH α-PARTICLES.

Yu.A.Nemilov, K.A.Gridnev and A.N.Pisarevskii.
Optika i Spektrosk. (USSR), Vol. 9, No. 6, 792 (Dec., 1960).
In Russian.

Reports studies of the slowly decaying component of luminescence of stilbene excited with Pu^{239} α-particles of ~4 MeV energy and with electrons produced by irradiation with 660 keV γ-rays from Cs^{137} (the maximum electron energy was 480 keV). It was found that the intensity of the slowly decaying component (relative to the total intensity) due to electrons was greater than the intensity reported by Brooks (Abstr. 7222 of 1959). With increase of dW/dX (see Abstr. 9898 of 1959) of the exciting particles (this quantity dE/dX increases from protons to α-particles) the relative intensity of the slowly decaying component increases. The results confirm Brooks' ideas on the nature of the slowly decaying component [English translation in: Optics and Spectrosc. (USA), Vol. 9, No. 6, 417-18 (Dec., 1960)]. A.Tybulewicz

6239

ELECTROLUMINESCENCE OF ZnSe:Cu WITH A Cu_2Se LAYER IN AN A.C. AND D.C. FIELD.

H.Łożykowski.
Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vo
No. 10, 719-24 (1960).

The phosphor ZnSe:Cu was converted to an electroluminopho
by the addition of a thin coating of Cu_2Se. Electroluminescence w
investigated with sinusoidal voltages 0 to 400 V at frequencies between 100 c/s and 15 000 c/s and with pulsed and d.c. voltages.
The luminescence from a suspension of the phosphor in castor oi
was red for a.c. fields and shifted to shorter wavelengths with d.c
The brightness waveform was dependent on the frequency of the a.c. field. The relation of the current through the cell to the appl
field strength was in agreement with the theory of thermal—elect
ionization. The phosphor was also dispersed in paraffin wax. A yellow luminescence was obtained, and the cell acted as a current
rectifier. At sufficiently large forward bias, the luminescent intensity was proportional to the current through the cell. It is suggested that this may be explained by impact excitation of the centres in strong-field regions of the phosphor. P.J.De

6240

ELECTROLUMINESCENCE OF ALKALINE EARTH SULPHIDE PHOSPHORS.

H.Łożykowski and H.Męczyńska.
Bull. Acad. Polon. Sci. Ser. Sci. math. astron. phys. (Poland), Vo
No. 10, 725-8 (1960).

Four types of BaS and SrS electroluminophors, each with distinctive emission, were prepared by heating a mixture of BaC
or $SrCO_3$ and the activator (Cu, Sn or Ag) in an atmosphere of H_2
The luminous intensity, B, followed the law $B = A\ e^{-b}/\sqrt{V}$, where
the applied voltage, was generally larger than the values typical
ZnS and CdS phosphors. The effect on the luminous intensity of variation of the frequency of the electric field between 300 c/s a
5000 c/s was measured for a BaS:Cu electroluminophor. The constant component of the intensity increased almost uniformly w
frequency, while the variable component saturated above 1500 c/
P.J.D

6241

A PARALLEL STUDY OF DEPOLARIZATION AND ELECTROLUMINESCENCE OF ZnS PHOTO-ELECTRETS.

V.M.Fridkin, A.N.Bogatȳrev and É.V.Brakhan.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2185-90 (Sept., 1960).
In Russian.

For abstract, see Abstr. 2463 of 1961. [English translation
Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1952-5 (March, 1961)].

6242

SOME ELECTROLUMINESCENT PROPERTIES OF $ZnO—Bi_2O_3$ MIXTURES.

É.G.Pettsol'd.
Izv. Akad. Nauk SSSR, Ser. fiz., Vol. 24, No. 1, 104-7; Disc. 108-
(1960). In Russian.

"1958 Moscow Dielectrics Conference" (see Abstr. 16003 of 1960). Constant voltages were applied to compacted powder mixtures of n-type ZnO and p-type Bi_2O_3. Yellow or blue electr
luminescence was observed near the electrodes. Studies of elect
luminescence and current as a function of the applied field and time (decay) showed that the observed effects were related to the
formation of space charge. A.Tybulew

6243

EXPERIMENTAL METHODS FOR THE DETERMINA OF PARAMETERS AND CONCENTRATIONS.

M.Sch
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, 155-69. In German.

"Electron processes in solids" conference (see Abstr. 2382
1961). The experimental techniques which are discussed include:
the study of glow curves and the changes in the emission of light under various conditions. P.T.Landsbe

6244

A REACTION-KINETIC EVALUATION PROCESS FO GLOW CURVES, WITHOUT LIMITING ASSUMPTION ABOUT THE SPECTRUM DUE TO TRAPS, AND ITS APPLICATION TO CdS AND ZnS.

K.Unger.
Abhandl. Deutschen Akad. Wiss. Berlin Kl. Math. Phys. Tech. (Germany), 1960, No. 7, p. 170-9. In German.

"Electron processes in Solids" conference (see Abstr. 2382
1961). Previous analyses of glow curves obtained from phosphor
cent materials have involved the assumption of a single-valued trapping level or of a particular trap distribution in energy. The
present analysis, starting from the usual equations for bimolecul
processes, makes less restrictive assumptions than these, and leads to equations which fit the known experimental data for CdS
and ZnS and enable dark zone glow curves to be analysed.
C.A.Hoga

6245 STIMULATED OPTICAL EMISSION FROM EXCHANGE-COUPLED IONS OF Cr^{+++} IN Al_2O_3.

I.Wieder and L.R.Sarles.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 95-6 (Feb. 1, 1961).

Fluorescence at wavelengths of 6934, 7010 and 7040 A in red ruby (0.7% Cr^{3+} by weight) was excited at 77°K by flashes of varying energy. At 6934 A, the number of radiating atoms increased approximately linearly with the excitation energy, and this line did not show the stimulated emission exhibited in pink ruby of much lower Cr^{3+} content. At 7010 and 7040 A, emissions which arise from exchange coupling between neighbouring Cr^{3+} ions (Abstr. 660 of 1960), stimulated emission was observed. The number of atoms radiating at 7010 A remained constant at excitation energies above a certain threshold, at which it appears that all equivalent ion pairs emitting 7010 A light are excited. Possible excitation processes for the coupled ions are discussed. J.Sheridan

6246 SIMULTANEOUS OPTICAL MASER ACTION IN TWO RUBY SATELLITE LINES.

A.L.Schawlow and G.E.Devlin.

Phys. Rev. Letters (USA), Vol. 6, No. 3, 96-8 (Feb. 1, 1961).

Pulsed maser oscillations were obtained simultaneously at 7009 and 7041 A from optically pumped "concentrated" ruby (0.5% Cr_2O_3) at liquid nitrogen temperatures (see also previous abstract). The expected threshold of pump power and the spatial coherence in the output were observed. Operation at low pump power is favoured by the termination of these emission transitions at levels above the ground state, and probably by efficient excitation mechanisms for the paired chromium ions involved (Abstr. 660 of 1960). Simultaneous maser action at two wavelengths shows that the lines at 7009 and 7041 A are not closely related in origin, and probably arise from different kinds of chromium ion pairs. J.Sheridan

MAGNETIC PROPERTIES OF SOLIDS

6247 THEORY OF THE MAGNETIC SUSCEPTIBILITY OF A POLARON. Dzh.I.Abakarov and Yu.M.Seiidov.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 8, 2264-7 (Sept., 1960). In Russian.

For abstract, see Abstr. 21023 of 1960. [English translation in: Soviet Physics--Solid State (USA), Vol. 2, No. 9, 2019-22 (March, 1961)].

6248 MEASUREMENT, BY MEANS OF THE MÖSSBAUER EFFECT, OF LOCAL FIELDS IN VARIOUS COMPOUNDS OF IRON. I.Solomon.

C.R.Acad. Sci. (France), Vol. 251, No. 23, 2675-7 (Dec. 5, 1960). In French.

The Mössbauer effect was observed in: (a) substances where the local field is zero; (b) substances where the instantaneous value of the local field is non-zero but due to the rapid fluctuations the average effect of the field is zero; (c) in a garnet where the measured values of the local field at two sites were found to be 390 ± 7 kOe and 490 ± 7 kOe with relative intensities 3 and 2, respectively. E.A.Sanderson

6249 MÖSSBAUER EFFECT: APPLICATIONS TO MAGNETISM. G.K.Wertheim.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 110S-117S (March, 1961).

The Mössbauer effect, the resonant absorption of nuclear gamma rays in solids, may be used to obtain the hyperfine structure of Fe^{57} in magnetic materials. Experiments are performed by observing the absorption by stable Fe^{57} of the 14.4 keV gamma ray coming from a source which contains radioactive Fe^{57} produced by the decay of Co^{57}. The experiments are not limited to naturally iron-bearing materials; other substances can be studied provided only that small amounts of cobalt can be introduced into lattice sites of interest. The magnetic moments of the ground and first excited states of Fe^{57} are known and make possible direct determination of the field at the iron nucleus once the hyperfine structure has been measured. The magnetic field at iron nuclei has been determined in the ferromagnetic transition metals (Fe 3.42×10^5 Oe, Co 3.12×10^5 Oe, Ni 2.80×10^5 Oe at 0°K) but no hyperfine structure has been observed down to 4°K in the antiferromagnetic transition metals, Mn and Cr. In the case of YFe-garnet the fields at the iron atoms in the two types of sites have been obtained (tetrahedral 3.9×10^5 Oe, octahedral 4.7×10^5 Oe). The most complete analysis so far has been made in FeF_2 where the magnetic field in the antiferromagnetic state ($H_{T=0} = 3.40 \times 10^5$ Oe) and the quadrupole splitting in the paramagnetic state (31.2 Mc/s) have been obtained. Other materials under investigation are the iron oxides and some ferrites, where, for trivalent iron, fields in the vicinity of 5.0×10^5 Oe have generally been found.

6250 RECENT ADVANCES IN MAGNETIC ANALYSIS. K.Hoselitz.

Brit. J. appl. Phys., Vol. 12, No. 4, 141-6 (April, 1961).

"Non-Destructive Testing" Conference, London, May 1960 (see Abstr. 5132 of 1961). Some recent developments in the examination of materials with the aid of the magnetization curve are described. The well-known method of estimating internal stresses by means of magnetic measurements has recently been much refined so that a quantitatively correct estimate of the internal stresses arising from plastic deformation of nickel and even iron can be made. In special cases even inhomogeneous stresses can be magnetically estimated and the approach to saturation is related to the dislocation density. A fair amount of information about non-magnetic inclusions and precipitates in a magnetic material can be derived from a critical assessment of its coercivity. On the other hand, the measurement of torque curves and of rotational hysteresis allows a comprehensive analysis of the shape, size and density of magnetic precipitates. Finally, the use of magnetic viscosity measurements for structure studies is mentioned.

6251 MAGNETIZATION PROCESS OF A HELICAL SPIN CONFIGURATION. U.Enz.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 22S-26S (March, 1961).

The behaviour of a helical spin configuration of a hexagonal crystal in an applied field is discussed for the case where the axis of the helix is identical with the hexagonal c axis and the magnetization vector in each layer is parallel to the basal plane. In a small field applied parallel to the basal plane, a slight deformation of the helix occurs resulting in a small increase in over-all magnetization. If the field surpasses a certain critical value, the helix changes abruptly into a state with high resulting magnetization. In this state the spin directions are oscillating about the direction of the applied field, the magnetization being about 85% of the saturation value. In still higher fields, saturation is reached completely. A helical spin configuration has been found in $MnAu_2$ by Herpin, Meriel, and Villain. The properties of the hexagonal oxide $(Ba,Sr)_2Zn_2Fe_{12}O_{22}$, which is of the Y-type, were investigated. The Ba-rich composition is ferrimagnetic and has a preferential plane for the magnetization at all temperatures. The Sr-rich composition has no spontaneous magnetization, but a magnetization equal to the one in the Ba case can easily be induced by an applied field. This behaviour can be explained by the assumption of a helical spin configuration. As another example, it is shown that the magnetic properties of dysprosium as investigated by Behrendt, Legvold, and Spedding can be explained by assuming a helical spin configuration between 85°K and 178°K. The angle between two neighbouring layers is equal to zero at 85°K, the ferromagnetic Curie temperature, and increases at higher temperatures. The magnetization process mentioned above is modified slightly in dysprosium by the presence of a strong magnetic anisotropy in the plane. In the presence of this anisotropy the transition between the ferromagnetic state and the helical state turns out to be a first-order transition, which explains the observed specific heat.

6252 LONG RANGE INTERACTIONS BETWEEN MAGNETIC MOMENTS IN SEMICONDUCTORS.

W.Baltensperger and A.M. de Graaf.

Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 881-8 (1960).

The interaction between magnetic moments embedded in a non-degenerate electron gas is calculated. In the fully degenerate gas the Ruderman-Kittel (Abstr. 11330 of 1954) interaction applies whereas in the Boltzmann gas the interaction is ferromagnetic only and of comparatively long range. Between these extreme cases the behaviour changes gradually. In a semiconductor an additional interaction comes from the virtual excitations of the valence band. These two interactions and the magnetic dipole interaction may be of comparable magnitude in dilute magnetic semiconducting alloys.

6253 MAGNETIC SUSCEPTIBILITY OF Ge–Si MIXED CRYSTALS.
G.Busch and O.Vogt.
Helv. phys. Acta (Switzerland), Vol. 33, No. 8, 889-910 (1960).
In German.

Measurements were made between 300 and 1200°K for a set of 34 samples. Assuming an ellipsoidal structure of the conduction band edge and two concentric spheres for the valence band edge it is possible to compare the present results with measurements of cyclotron resonance and magnetoresistance. The effective masses for holes and electrons are calculated over the whole concentration range. Using the deformation potential formula it is possible to visualize the change of energy band edges as a function of composition.

6254 STUDY OF THE DIAMAGNETISM OF SINGLE CRYSTALS OF GRAPHITE.
E.Poquet, N.Lumbroso, J.Hoarau, A.Marchand, A.Pacault and D.E.Soule.
J. Chim. phys. (France), Vol. 57, No. 10, 866-72 (Oct., 1960).
In French.

The principal magnetic susceptibilities of single crystals of graphite have been measured in the temperature range 77° to 1100° K. At 292° K the susceptibilities have the values -0.3×10^{-6} and -21.0×10^{-6} c.g.s. units. The accuracy claimed is higher than that of Krishnan and Ganguli (Abstr. 2636 of 1939) and although the present results are in qualitative agreement with earlier investigations there are considerable differences in detail. The variation of susceptibility with temperature can be represented by an equation of the type $K/K_0 = 1 - \exp(-T_0/T)$. J.Iball

6255 EXCHANGE ANISOTROPY IN MIXED MANGANITES WITH THE HAUSMANNITE STRUCTURE.
I.S.Jacobs and J.S.Kouvel.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 274S (March, 1961).

Only a short account of the paper is given, substantially as follows. Magnetic properties are reported of powder compounds isomorphous to hausmannite, but containing partial to nearly complete substitution of diamagnetic Zn^{2+} or Mg^{2+} ions in the tetrahedral sites of Mn_3O_4. X-ray diffraction of these compounds reveals a single phase, whose structure corresponds to a tetragonally distorted spinel. Unidirectional anisotropy is present and is detected by the observation of hysteresis loops displaced along the field axis when the materials are cooled to low temperatures in magnetic fields of several kOe. The unidirectional behaviour is stable to reverse field pulses of 140 kOe. An exchange anisotropy model is proposed involving interactions between ferrimagnetic and nearly antiferromagnetic regions brought about by the random distribution of the diamagnetic ions among the tetrahedral sites and the consequent magnetic inhomogeneity. This model is similar to that proposed for disordered alloy systems. Magnetic viscosity effects are observed which correspond in part to ordinary magnetic viscosity, but which are influenced by the presence of unidirectional anisotropy. The identity of this anisotropy is not impaired by the ordinary viscosity effects. In addition, observations of certain differences in the hysteresis loops measured dynamically and quasi-statically reveal an "extra-ordinary" viscosity associated with a gradual breakdown of the unidirectional anisotropy.

6256 THEORY OF THE DE HAAS–VAN ALPHEN EFFECT FOR A SYSTEM OF INTERACTING FERMIONS.
J.M.Luttinger.
Phys. Rev. (USA), Vol. 121, No. 5, 1251-8 (March 1, 1961).

Granting certain analytic properties (which were used before in establishing the existence of a Fermi surface, and which have only been established in the sense of perturbation theory), it is possible to obtain a simple expression for the oscillatory part of the thermodynamic potential. In particular, it is found that the de Haas–van Alphen oscillations have the same amplitude and period as in the usual quasi-particle picture, but that the phase is given by a more complicated procedure.

6257 THERMOMAGNETIC STUDY OF DILUTE Pd–Cr HYDROGENIZED ALLOYS.
J.P.Burger and J.Wucher.
C.R. Acad. Sci. (France), Vol. 251, No. 23, 2667-9 (Dec. 5, 1960).
In French.

Five alloys containing between 1.0 and 9.75 at.% Cr were studied. The susceptibilities of the hydrogenized alloys follow a Curie–Weiss law in the range 85-300° K with a Curie constant corresponding to a moment intermediate between Cr^{++} and Cr^{+++}. The paramagnetic Curie points decrease from -35 to -290° K as the concentration of Cr increases. A.J.Manuel

6258 LOW-TEMPERATURE MAGNETIC SUSCEPTIBILIT OF THE HYDRATED ACETATES OF Ni^{++}, Co^{++}, AND Mn^{++}.
R.B.Flippen and S.A.Friedberg.
Phys. Rev. (USA), Vol. 121, No. 6, 1591-8 (March 15, 1961).

The magnetic susceptibilities of powdered $Ni(C_2H_3O_2)_2 \cdot 4H_2O$ $Co(C_2H_3O_2)_2 \cdot 4H_2O$, and $Mn(C_2H_3O_2)_2 \cdot 4H_2O$ were measured in the liquid hydrogen and helium ranges by an a.c. mutual inductance method. Measurements on the cobalt salt were extended to 0.4° revealing a sharp maximum at 0.6°K. A similar, more pronounc susceptibility peak is observed in the manganous acetate at 3.2° Single crystal measurements have been made on the latter salt along the monoclinic b axis as well as in the ac plane. $Mn(C_2H_3O_2)_2 \cdot 4H_2O$ appears to be a weak ferromagnet of the kind discussed recently by Dzyaloshinsky and Moriya.

6259 PARAMAGNETISM OF POLYCRYSTALLINE GADOL IUM, TERBIUM, AND DYSPROSIUM METALS.
S.Arajs and R.V.Colvin.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 336S-337S (March 1961).

The paramagnetic susceptibilities of polycrystalline gadolin terbium, and dysprosium metals have been studied between 300– 1500° K. The measurements are in good agreement with predict which use the localized f-electron model of interacting rare-ear ions and the Van Vleck theory of paramagnetism. Departures fr the Van Vleck theory are attributed to paramagnetism of conduc electrons. An approximate value of this contribution has been calculated for dysprosium.

6260 MAGNETIC INTERACTION OF CERIUM AND COBA IONS IN DOUBLE NITRATE CRYSTALS.
J.W.Culvahouse, W.Unruh and R.C.Sapp.
Phys. Rev. (USA), Vol. 121, No. 5, 1370-8 (March 1, 1961).

The space group of the double nitrate crystals $M_2'M_3''(NO_3)_{12}.24H_2O$, where M' is a trivalent cation and M'' is divalent cation, was determined from X-ray data to be $R\bar{3}m$. Th rhombohedral unit cell has sides of 13.1 A, interaxial angles of and contains one molecule. The cerium ions have the locations $\pm(\frac{1}{4},\frac{1}{4},\frac{1}{4})$. The line shapes of the derivative with respect to mag field of the paramagnetic resonance absorption of small concentrations of cobaltous ions substituted in $Ce_2Zn_3(NO_3)_{12}.24H_2O$ are described and used to determine the spatial relations of the ceri ions and cobalt ions, as well as to justify the assumption of a di interaction between them described by the spin Hamiltonian parameters of the cerium and cobalt ions. It is concluded that the m isotropic of the two paramagnetic spectra of cobalt ions observe this salt is due to ions in either the special sites ±(0.399, 0.399, or, rather less likely, in the special sites ±(0.101, 0.101, 0.101) that the highly anisotropic spectrum of cobalt ions is due to ions the body-centred site.

6261 ELECTRIC QUADRUPOLE SPLITTING AND THE NUCLEAR VOLUME EFFECT IN THE IONS OF Fe
S.DeBenedetti, G.Lang and R.Ingalls.
Phys. Rev. Letters (USA), Vol. 6, No. 2, 60-2 (Jan. 15, 1961).

The Mössbauer spectra of Fe^{57} was studied in several chemical compounds of both ferrous and ferric iron. The quadr splitting and the shift of the centre of gravity of the spectrum, d partially to the second-order Doppler effect and partially to a nuclear size effect, are tabulated and discussed. J.M.B

6262 INTERPRETATION OF THE Fe^{57} ISOMER SHIFT.
L.R.Walker, G.K.Wertheim and V.Jaccarino.
Phys. Rev. Letters (USA), Vol. 6, No. 3, 98-101 (Feb. 1, 1961).

A systematic study was made of the Mössbauer effect of Fe di- and trivalent iron compounds and in d-group metals. The observed "isomer shift" measures the total s-electron density at nucleus. The shift in compounds is shown to depend mainly upo 3d configuration of iron involved and to a lesser extent upon the "chemical" bond. The Hartree–Fock calculations of Watson (unpublished) on the various 3d configurations of iron are combine with the data on the shifts in the most ionic compounds to obtain calibration of the shift in terms of s-electron density. The evid given by the results, about the electronic configuration of the ir the various specimens is discussed. J.M.B

6263 SOME COUNTING THEOREMS IN THE THEORY OF ISING MODEL AND THE EXCLUDED VOLUME PROBLEM.
M.F.Sykes.
J. math. Phys. (USA), Vol. 2, No. 1, 52-62 (Jan.-Feb., 1961).

The problem of the exact enumeration of self-avoiding rand walks on a lattice is studied and a theorem derived that enables mber of such walks to be calculated recursively from the number a restricted class of closed graphs more easily enumerated than e walks themselves. The method of Oguchi for deriving a high-mperature expansion for the zero-field susceptibility of the Ising odel is developed and a corresponding theorem enabling the ccessive coefficients to be calculated recursively from a restricted ass of closed graphs deduced. The theorem relates the susceptility to the configurational energy and enables the behaviour of the tiferromagnetic susceptibility at the transition point to be inferred.

6264 USE OF SERIES EXPANSIONS FOR THE ISING MODEL SUSCEPTIBILITY AND EXCLUDED VOLUME PROBLEM.

.Domb and M.F.Sykes.
math. Phys. (USA), Vol. 2, No. 1, 63-7 (Jan.-Feb., 1961).

Discusses the problem of making the most effective use of the oefficients of series expansions for the Ising model and excluded olume problem in estimating critical behaviour. It is shown that ter initial irregularities the coefficients appear to settle down to a nooth asymptotic behaviour. Alternative methods of analysis are onsidered for the provision of a steady series of approximations to e critical point. Numerical conclusions are drawn for particular ttices for which additional terms have recently become available.

6265 FERROMAGNETIC SPIN WAVES.

R.Brout.
uppl. to Physica (Netherlands), Vol. 26, S215-S217 (Dec.,1960).

International Conference on Many-Particle Problems,Utrecht, 960 (see Abstr. 1707 of 1961). The random phase approximation ives correct results for a ferromagnetic system both at very high emperatures and at very low temperatures. It can be used to interolate between these regions. The Curie point found in this way grees with the result of the spherical model. D.J.Thouless

6266 SIMPLE PHYSICAL THEORY OF SPIN WAVE INTERACTIONS.

F.Keffer and L.Loudon.
. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 2S-7S (March, 1961).

A simple and powerful new method for the treatment of spin vave interactions is introduced and used to obtain the corrections o the energy and magnetization of ferromagnets, antiferromagnets nd ferrimagnets. The results previously obtained by Dyson and by)guchi using complicated analysis are reproduced and extended by neans of elementary considerations which throw light on the hysical interpretation of the corrections. In the case of a ferronagnet the validity of the random phase approximation is discussed, nd the properties of the continuous medium model are calculated: n particular, the spin wave exchange-collision cross-section is btained in a simple way.

6267 THE EXCITATION OF THE SPIN SYSTEM OF A FERROMAGNETIC BY A SPATIALLY NON-UNIFORM ELECTROMAGNETIC FIELD.

E.I.Yakovlev.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 5, 1067-9 (Aug. 11, 1960).
n Russian.

For abstract, see Abstr. 21034 of 1960. [English translation n: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 847-9 (Jan.-Feb., 1961)].

6268 MAGNETIC ORDERING IN THE FERROMAGNETIC RARE-EARTH METALS.

K.Yosida and H.Miwa.
. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 8S-12S (March, 1961).

The ferromagnetic rare-earth metals show the magnetic ransition from the ferromagnetic state to the antiferromagnetic tate. The possibility of this kind of magnetic transition between pin arrangements is discussed on the basis of the spin wave pproximation. It is shown that the transition from the ferromagnetic the helical spin arrangement which has recently been observed in ysprosium and holmium can occur when a large axial anisotropy eld exists. The temperature dependence and the field dependence the pitch of the helical structure are calculated on the same standoint of the spin wave theory.

6269 ON THE CONTRIBUTION OF THE FERMI CONTACT TERM TO THE MAGNETIC FIELD AT THE NUCLEUS.

.E.Watson and A.J.Freeman.
. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 118S-119S March, 1961).

The dominant source of the effective magnetic field at the iclei in ferromagnets apparently comes from the Fermi contact ontribution of the s electrons in the core. This contribution was ivestigated for transition element atoms and ions by means of a eries of spin (or exchange) polarized Hartree—Fock calculations alculations where one-electron orbitals of differing m_s are allowed different radial dependence). Calculations were done for both free-atom and crude crystalline environments. The sensitivity of the 3s electrons to 3d behaviour was found to contribute to large differences in calculated effective fields. The differences between core polarizations in metals and ions are discussed with the use of a model for metallic iron (i.e., a $3d^8$ configuration) which is more consistent with neutron-diffraction and energy-band results than the free atom $3d^6$ state (the spin polarized $3d^8$ calculation shows an expanded 3d charge density but an almost unchanged spin density relative to the $3d^6$ results). The resultant (negative) increase in the effective field is not, however, large enough to overcome the positive contributions of the outer electrons so that although a net negative field is found it is not large enough in magnitude to agree with the Mössbauer measurements. A parallel calculation by Goodings and Heine, based on an artificially expanded 3d charge and spin densities, is also found to be similarly deficient. Their model is discussed and shown to be incompatible with neutron experiments and energy-band calculations.

6270 A STUDY OF HEAT TREATMENT OF MAGNETICALLY SOFT ALUMINIUM—IRON ALLOYS.

G.V.Krasnoperov and N.I.Lapkin.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 668-71 (Nov., 1960). In Russian.

Reports a study of the effect of the quenching temperature and the quenching medium (oil, water, alkali) on the magnetic properties of the 16% Al—Fe alloy (Alfenol) previously subjected to annealing at two different temperatures. Gives heat-treatment conditions ensuring high permeability and low coercive force in hot-rolled sheets of the alloy. A.Tybulewicz

6271 CONTRIBUTION TO THE FERRO—ANTIFERROMAGNETIC EXCHANGE PHENOMENA AND THE MAGNETIC PROPERTIES OF B8-TYPE ANTIMONIDES OF CHROMIUM, IRON, COBALT AND NICKEL.

H.Schmid.
Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 15-29. In German.

Ferro—antiferromagnetic exchange interaction is reported for the systems Ni—NiO and $[Co_x, Ni_{1-x}]-[CoO_x, NiO_{1-x}]$. This can be demonstrated by rotational hysteresis and by torque curves. The crystallographic orientations of the antiferromagnetic oxides with respect to the metal substrates are determined. The susceptibility of $CoSb_x$, $FeSb_{0.8}$, $CoSn_{0.7}$, $Co_xCr_{1-x}Sb$ and $Cr_{0.75}Fe_{0.25}Sb$ is found to be paramagnetic and that of NiSb is diamagnetic. These results can understood in terms of Pauli's theory of paramagnetism in metals. R.Parker

6272 SYNTHESIS AND PROPERTIES OF FERROMAGNETIC CHROMIUM OXIDES.

T.J.Swoboda, P.Arthur,Jr, N.L.Cox, J.N.Ingraham, A.L.Oppegard and M.S.Sadler.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 374S-375S (March, 1961).

Ferromagnetic chromium oxides of high purity have been synthesized by thermal decomposition of chromium trioxide in the presence of water at elevated pressure. These materials consist entirely of a rutile-type crystalline phase with cell constants $a_0 = 4.41 \pm 0.01$ A and $c_0 = 2.91 \pm 0.01$ A and have compositions that are very close to the exact stoichiometry of the dioxide, CrO_2. Saturation specific magnetizations of these oxides are in the range of 98-100 e.m.u./g at room temperature and their Curie temperatures are about 126° C. By using different reaction conditions, it is possible to obtain either microcrystalline particles from 3-10 μ in length and from 1-3 μ in width or single crystals of fractional millimeter size that are suitable for physical studies. In addition, elongated single-domain crystals only 0.5-1.5 μ in length and with length-to-width ratios of 8 : 1 or higher can also be obtained merely by adding catalytic amounts of Sb_2O_3 or RuO_2 under hydrothermal synthesis conditions.

6273 POLARIZATION OF THE CONDUCTION ELECTRONS IN THE FERROMAGNETIC METALS.

A.J.F.Boyle, D.S.P.Bunbury and C.Edwards.
Phys. Rev. Letters (USA), Vol. 5, No. 12, 553-6 (Dec. 15, 1960).

The determination of the magnetic field H_c at a nucleus due to the polarization of conduction electrons in a ferromagnetic material was attempted by studying the Zeeman splitting of the 24 keV transition in Sn^{119} dissolved in Fe, Co and Ni. The alloys contained 1% Sn^{119}. The signs and magnitudes of the fields deduced are inconsistent with a single field H_c. It is suggested that this is due to the spatial redistribution of electrons of opposite spin about the Sn^{119} atoms due to the polarization of the 3d shells of the neighbouring ferromagnetic atoms. A.J.Manuel

6274 ANISOTROPIC CURIE TEMPERATURE.
E.R.Callen.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 221S-222S (March, 1961).

In an anisotropic ferromagnet the Curie temperature is a function of the direction of the magnetization. The Curie temperature is high in easy directions, and can drop quite low in harder directions for large ratio of anisotropy to exchange energy. Magnetization curves as a function of temperature also depend upon the orientation. In sufficiently hard directions, the magnetization drops from a large value precipitously to zero at the Curie temperature.

6275 LOW-TEMPERATURE PYROMAGNETIC MEASUREMENTS ON NICKEL.
E.W.Pugh and B.E.Argyle.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 334S-335S (March, 1961).

A new technique is described for making low-temperature measurements of magnetization changes with temperature by using the pyromagnetic effect. Its sensitivity is one to two orders of magnitude better than previous methods in which the total magnetization is measured at each temperature. The magnetization of a nickel single crystal was found to decrease monotonically from 4.2° to 50°K without an anomalous dip near 10°K as has been previously reported.

6276 ON THE UNIAXIAL MAGNETIC ANISOTROPY OF THIN ELECTROLYTICALLY PREPARED LAYERS.
W.Andrä and O.Stemme.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 104-8. In German.

Measurements of the anisotropy and loss in thin nickel layers (500-10 000 A) were made under nearly static conditions. The resultant properties were found to depend markedly on the conditions of preparation and on the subsequent treatment, e.g. heating while in a magnetic field. C.A.Hogarth

6277 MAGNETIC ANISOTROPY OF DISPERSED POWDERS.
F.D.Stacey.

Austral. J. Phys., Vol. 13, No. 2, 196-201 (June, 1960).

In a study of magnetic properties of rocks, the magnetic anisotropies were measured for a number of artificial specimens consisting of ferromagnetic materials: iron, nickel and magnetite dispersed in various non-ferromagnetic matrices. The apparatus used is described. Results show that single-crystal magnetic grains align themselves with the magnetic lines of force to produce strongly anisotropic specimens only when the first magnetocrystalline anisotropy constant is positive. S.A.Ahern

6278 EXCHANGE ANISOTROPY IN STAINLESS STEEL.
W.H.Meiklejohn.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 274S-275S (March, 1961).

"Nonmagnetic" stainless steel is a paramagnetic material at room temperature with a face-centred cubic lattice structure. It has been shown by Kondorskii and Sedov that the susceptibility has an anomaly at 40°K which is quite characteristic of an antiferromagnetic transition. The result suggested that cold working such a material to transform part of the material to the ferromagnetic body-centred cubic structure might yield a shifted hysteresis loop, if the b.c.c. structure is in exchange contact with the f.c.c. material. A cold-worked (swaged) type 347 stainless steel did develop a shifted hysteresis loop when cooled in a magnetic field from room temperature to 4.2°K, while the hysteresis loop was symmetrical when the material was cooled in a zero magnetic field. The shift of the hysteresis loop was measured as a function of temperature and found to disappear at 40°K, in agreement with the susceptibility measurements of Kondorskii and Sedov (Abstr. 13446 of 1959).

6279 MAGNETOCRYSTALLINE ANISOTROPY OF Fe—Si ALLOY CRYSTALS UNDER HYDROSTATIC PRESSURE.
J.S.Kouvel and R.H.Wilson.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 276S-277S (March, 1961).

Magnetization measurements at room temperature were made for various fields applied in ⟨100⟩, ⟨110⟩, and ⟨111⟩ directions of 6 at. % Si in Fe alloy crystals subjected to hydrostatic pressure up to 5100 bar. All the experimental results are found to agree closely with theoretical curves computed for $K_1^{-1}(\partial K_1/\partial p) = -60$, $K_2^{-1}(\partial K_2/\partial p) = 0$, and $\sigma_S^{-1}(\partial \sigma_S/\partial p) = -5.5$ (all in 10^{-7} bar^{-1}), where the anisotropy constants K_1 and K_2 are 46 and 7 (in 10^3 erg/g), respectively, and the saturation moment σ_S is 204 e.m.u. These values for the pressure dependences of K_1 and σ_S, when converted to volume dependences and combined with thermal dilatation data can account for some but only a small part of the discrepancy between recent measurements on this alloy and the theoretical 10th-power relation between the variations of K_1 and σ_S with temperature. A similar situation is shown to obtain for pure iron.

6280 INDUCED MAGNETIC ANISOTROPY CREATED BY MAGNETIC OR STRESS ANNEALING OF IRON—ALUMINUM ALLOYS.
H.J.Birkenbeil and R.W.Cahn.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 362S-363S (March, 1961).

Polycrystalline samples of five Fe—Al solid solutions were subjected to various heat treatments (1) in a strong magnetic fiel or (2) under tensile stress. For treatment (1) the samples were in the form of cylinders, while in case (2) they were machined int this form after stress treatment. Torque—azimuth plots were obtained from each sample by means of a torque magnetometer; further heat treatments were then applied, followed again by torq measurements, to permit correction for the intrinsic anisotropy resulting from unavoidable preferred orientation of grains. The maximum value of anisotropy, whether field or stress induced, arises at 21-22 at.% aluminium. Induced anisotropy energies of up to 17 000 ergs/cm³ were recorded. A variety of heat treatmen were used to explore the inhibiting effect of spontaneous long- or short-range order on the development of induced anisotropy. Thi inhibiting effect is pronounced, and in stoichiometric Fe_3Al it is possible to prevent almost completely the creation of induced ani tropy. Such inhibition is to be expected if the induced anisotropy caused by directional order. A close correspondence is observe between the composition dependence of induced anisotropy and tha of the Zener internal friction.

6281 MAGNETIC PROPERTIES OF THE LOW-TEMPERATURE FORM OF MAGNETITE.
D.B.Bonstrom, A.H.Morrish and L.A.K.Watt.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 272S-273S (March, 1961).

Some of the magnetic properties of the orthorhombic form o magnetite (Fe_2O_3) have been studied from 2°K to the transition temperature (~119°K). Both ferromagnetic resonance measure on single crystals and coercive force measurements on small pa cles have been made. The "twinning" of orthorhombic magnetite has been investigated. The crystalline anisotropy constants have been determined; they are of the order of 10^6 ergs/cm³. The coercive force of single-domain and multidomain particles has bee interpreted in terms of the crystalline anisotropy.

6282 STUDIES OF MAGNETIZATION OF THIN WIRES.
G.Vasiliu.

Stud. Cercetarii stiint., Fiz. Stiint. tehn (Roumania), Vol. 11, No. 19-28 (1960). In Roumanian.

Using a thin wire of iron or nickel carrying a sinusoidal current and surrounded by a co-axial pick-up coil, the appearanc of an e.m.f. in the coil is explained in terms of the rotating components of the magnetic field. The following formula is given for the longitudinal component of magnetic induction:

$$B_1 = \tfrac{1}{2}(\mu_X - \mu)H.\sin 2\alpha,$$

where μ_X is the permeability in the preferential direction, μ the permeability in other directions, H is the magnetic field due to th wire current and α is the angle between the direction of preferen magnetization and a perpendicular to the wire. B_1 increases whe the wire is under torsional stress: opposing directions of torsio give phase coincidence or opposition between B_1 and H. The measuring apparatus is described. A.Re

6283 THE INFLUENCE OF THE METHOD OF DEMAGNETIZATION ON THE PERMEABILITY IN SOFT MAGNETIC MATERIALS.
A.Smolinski.

Brit. J. appl. Phys., Vol. 12, No. 2, 81-2 (Feb., 1961).

Permeability curves as a function of applied a.c. fields of up to 1 Oe are reported for specimens of silicon steel and Permallo previously demagnetized by (a) cooling from the Curie point and (b) slowly withdrawing from a large a.c. demagnetizing field. Measured permeabilities were found to be up to 40% greater afte process (b) than after (a). Some results are presented also for specimens which were heat-treated below the Curie point. No theoretical explanation is as yet available. R.Par

6284 ON THE INFLUENCE OF NON-METALLIC INCLUSIONS ON THE DEMAGNETIZATION LOSSES OF SILICON–IRON TRANSFORMER LAMINATIONS.

F.Pawlek and D.Seeger.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 168-74. In German.

The impurities were electrochemically extracted after determination by means of X-ray diffraction studies. Different contents of impurities remained after heating to red-heat in vacuum. The reduction in impurity content gave rise to smaller iron losses in accordance with the theory of Kersten and Néel. C.A.Hogarth

6285 UNIDIRECTIONAL PROPERTIES IN THE IRON–IRON SULFIDE SYSTEM.

J.H.Greiner, I.M.Croll and M.Sulich.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 188S-189S (March, 1961).

The unidirectional properties and the nonvanishing rotational hysteresis for applied fields $>2K/I_s$ are ascribed to exchange anisotropy between ferromagnetic iron and antiferromagnetic iron sulphide. Torque curves, measured on samples cooled in a magnetic field, depended upon the percentage of iron, temperature, and applied field. Maximum torques at -196°C for 6000 Oe increased from 2×10^6 to 1.5×10^7 dyn-cm/cm^3 of ferromagnetic Fe for a decrease in iron percentage of 4.5-0.87%. This is attributed to a decrease in particle size with decreasing iron percentage, thereby enhancing the unidirectional properties. The decrease of the $\sin\theta$ dependence of torque at high fields is explained by a reorientation of the moments of the antiferromagnetic iron sulfide. The fact that a $\sin\theta$ term is present after a reorientation of the moments in the antiferromagnetic material indicates that the coupling between the moments of the iron and the iron sulphide across the interface remains, but has been realigned. Iron sulphide has a Néel temperature of 340°C and a reordering temperature near 140°C where the spins change their ordering direction by 90°. The significance of the reordering temperature is evident from the rapid decrease in rotational hysteresis as the reordering temperature is approached and also from the absence of an increase in maximum torque upon cooling in a field from temperatures greater than 150°C.

6286 STUDIES OF A HIGH-COERCIVITY ELECTRODEPOSIT HAVING A LAMELLAR STRUCTURE.

J.S.Sallo and K.H.Olsen.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 203S-204S (March, 1961).

A cobalt–nickel–phosphorus electrodeposit having a 60-cycle coercive force of 1000 Oe was studied. Electron micrographs of the surface indicate that lamellar structure is present. The lamellas occur in oriented clusters. Diffraction and magnetic studies show the material to be hexagonal with its uniaxial easy direction of magnetization (c axis) in the plane of the film. A Bitter pattern technique utilizing the high resolving power of the electron microscope shows that in a demagnetized sample, fields leave the plane of the film at lamellas cluster boundaries. In a magnetized sample, no fields leave the plane of the film. Studied of cross sections confirm the existence of the lamellar cluster structure. The results are explained on the basis of a model which considers each lamella to be a single-domain particle.

6287 ANALYTIC HYSTERESIS FUNCTION.

F.H.Middleton.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 251S-252S (March, 1961).

An analytic function is proposed in a parametric form which displays the character of an adjustable hysteresis loop. The type of function used was suggested by the phase-frequency characteristic of a conventional phase shift network. There are two parameters in the analytic function, one of which controls the width of the loop, and the other, the steepness of the sides of the loop. These two parameters are related to the conventional magnetic parameters such as coercivity, residual induction, etc., so that one may construct a synthetic loop corresponding to a given experimental loop. The analytic function was used to produce equations for the Fourier series components of b and h in terms of the two parameters. The mathematics is omitted in the paper but the results are given, and an application of the results is made to some experimental data. A typical set of c.r.o. photographs is used to display a family of synthetic loops produced by an analogue computer arranged to generate voltages corresponding to the analytic function.

6288 FERROMAGNETIC PHASE OF Mn–Al.

R.B.Campbell and C.A.Julien.

J. appl. Phys. (USA) Suppl. to Vol. 32, No. 3, 346S-347S (March, 1961).

The metastable, ferromagnetic, tetragonal phase in the Mn–Al system was obtained by isothermal transformation of a high-temperature phase. Transmission electron micrographs of specimens of this phase so obtained (bulk ${}_iH_c$ = 1130 Oe) show striations of light (transmitting) and dark (non-transmitting) material. The striations are presumed to arise from stresses induced by the transformation and/or cooling. Transmission electron diffractograms contain individual patterns both with and without superlattice reflections. Respective patterns reveal axial ratios of 0.90 and 0.94, and are correlated with the dark and light areas of the micrographs. From diffraction data it is concluded that the trace of the boundary beween the light and dark regions coincides with a projection of the c axis. The possibility of coherency as a mechanism for the high coercive force, analogous to CoPt, is discussed. The type of cooperative atomic interaction as related to the shift in the axial ratio is also discussed.

6289 IMPROVED MAGNETIC PROPERTIES OF HIGH-PURITY IRON–COBALT ALLOYS CONTAINING 27-43% COBALT.

D.S.Shull, Jr.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 356S-357S (March, 1961).

Interest in iron–cobalt alloys has revived in the last several years because of their high saturation inductions and high Curie temperatures. The development of Supermendur in 1957 demonstrated that outstanding improvements in the magnetic properties of the 49% Fe–49%Co–27% V alloycan be obtained by careful processing and magnetic annealing. This paper describes a survey of the magnetic properties obtained when similar techniques are applied to alloys containing 27-43% cobalt. Significant improvements in both the d.c. and 400 c/s properties were obtained, compared to previous similar compositions of lower purity. The alloys containing 35-43% cobalt with additions of chromium or vanadium had 400 c/s core losses approaching those of Supermendur.

6290 LOSSES IN SILICON IRON AT VERY LOW FREQUENCIES AND HIGH FLUX DENSITIES.

D.A.Wycklendt and R.M.Kay.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 368S-369S (March, 1961).

Past measurements of losses in soft magnetic materials magnetized to high flux densities have been largely confined to determination of a quasi-static hysteresis loss over a nondescript cycle of magnetization and losses with sinusoidal magnetization with frequencies greater than 15 c/s. However, since the simple concept of a hysteresis loss combined with an eddy current loss in a homogeneous medium has become outmoded, measurements of losses resulting from sinusiodal magnetization over a frequency spectrum from near-zero to power frequencies are desirable. This paper describes losses in (110) [001] textured silicon iron strips which were magnetized with sinusoidal induction of negligible distortion in the frequency range 0.02 to 100 c/s. Flux density amplitudes of 10, 15, and 17 kG were used. A direct-coupled amplifier with very large negative feedback and a low distortion oscillator were used to excite the specimens. Losses in the range 0.02-0.4 c/s were obtained from loop measurements; bridge measurements were made in the range 0.4-100 c/s. The measurements reveal a sharp drop in the loss per cycle as the frequency is decreased from 1.5 to 0.02 c/s. The downward concavity of the loss-frequency curve which has been observed previously for the power frequency range is therefore, even more prominent at very low frequencies. The effect increases with the amplitude of the flux density.

6291 REMANENT MAGNETIZATION OF A SYNTHETIC HEMATITE SINGLE CRYSTAL.

S.T.Lin.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 394S-395S (March, 1961).

The remanence of a virgin sample of a synthetic single crystal of haematite was carefully measured along different directions through a temperature range between 77° and 420°K. The effect of a directive field as applied through the low temperature transition on the remanence also has been studied. Some remarkable phenomena in constrast with those of the natural crystal were recognized.
(1) There is no weak ferromagnetism along the [111] direction.
(2) The weak ferromagnetism is strictly limited to the (111) plane above the Morin transition and sharply reduced to zero below 259°K. The thermal hysteresis of the remanence–temperature curve forms a perfect square loop. (3) If the sample were warmed through tran-

sition in zero external magnetic field no ferromagnetism could be observed along any direction in the crystal. This leads to the conclusion that the antiferromagnetic axes form equilateral triangular arrangement in the basal plane (111) above transition. The experimental data support the phenomenological theory of weak ferromagnetism of Dzyaloshinsky and Vonsovsky.

6292 INVESTIGATION OF THE INITIAL MAGNETIC SUSCEPTIBILITY OF A CRYSTAL OF NICKELIFEROUS IRON.

S.S.Fonton.

Kristallografiya (USSR), Vol. 5, No. 1, 151-2 (Jan-Feb., 1960). In Russian.

Kondorskii has shown that the initial susceptibility χ_0 will be isotropic if the distribution of the magnetization amongst the easy axes is equal. Williams (Abstr. 2616 of 1949) has examined picture-frame specimens of single crystals in which $\chi_{[100]} : \chi_{[110]} : \chi_{[111]}$ are as 6 : 3 : 2. The present paper describes results for larger crystals in which χ_0 is isotropic. This demonstrates that the initial demagnetized crystal does not possess a preferred easy axis. [English translation in: Soviet Physics—Crystallography (USA), Vol. 5, No. 1, 142-4 (July-Aug., 1960)].

D.J.Oliver

6293 THE MAGNETIC SUSCEPTIBILITY OF SILICON BRONZE (EVERDUR 1010) IN HIGH FIELDS.

D.N.Lyon and T.E.Hopkins.

Rev. sci. Instrum. (USA), Vol. 32, No. 1, 92-3 (Jan., 1961).

Since the 100 kOe solenoid magnet used by the authors was wound on seamless silicon bronze, the susceptibility of alloys of the same composition (Fe, 0.0008 wt%; Mn, 0.86 wt%; Si, 3.31 wt%; the balance being copper), was determined by the Gouy method. The material is not of constant susceptibility and for fields above 20 kOe the results fit an expression for the volume susceptibility $\chi_v = 10.41 \times 10^{-6} - 9.40 \times 10^{-9} H^{1/2}$.

C.A.Hogarth

6294 THE INFLUENCE OF BLOCH WALL MOTIONS ON THE DAMPING OF ULTRASONIC WAVES IN FERROMAGNETIC METALS.

G.Simon.

Ann. Phys. (Germany), Vol. 7, No. 3-4, 140-8 (1961). In German.

6295 CHANGE OF MAGNETIC STRUCTURE OF RESIDUALLY MAGNETIZED SILICON—IRON CRYSTALS WHEN DEMAGNETIZED BY ALTERNATING FIELDS.

Ya.S.Shur and I.E.Startseva.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 4, 614-20 (1958). In Russian.

Gives powder-pattern photographs of the domain structure in 3.5% Si—iron of grain size 0.5-2 mm when demagnetized from remanence by a.c. fields and describes the domain patterns observed in selected crystallites when these pass from the remanent to the demagnetized state. The remanent domain structure is not reproducible in detail as a result of repeated application of the same magnetic field. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 4, 35-40 (1958)].

R.Parker

6296 STUDY OF MAGNETIZATION PROCESSES IN CRYSTALS OF SILICON—IRON.

Ya.S.Shur and V.R.Abel's.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 556-63 (1958). In Russian.

The domain structure in thin disks of polycrystalline 3.5% silicon—iron was observed by the Bitter figure technique and the results of earlier work are confirmed. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 167-73 (1958)].

R.Parker

6297 THE INTERPRETATION OF DOMAIN STRUCTURES INDUCED BY TENSION IN THE ALLOY 50Ni50Fe.

C.Greiner.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 15-29. In German.

Bitter figures were observed in thin wires of 50-50% Ni—Fe alloy. These were found to be complicated and sensitive to the applied tension. A qualitative interpretation is attempted, a distinct feature of which is the assumption that magnetic poles exist both on the surface and on the domain walls.

R.Parker

6298 STABILIZATION OF DEFINABLE DOMAIN STRUCTURES BY INTERSTITIAL ATOMS.

J.Bindels, J.Bijvoet and G.W.Rathenau.

Physica (Netherlands), Vol. 26, No. 3, 163-74 (March, 1960).

The stabilization by interstitial atoms of 180° walls and 90° walls was studied separately in 3.25 wt% silicon-iron single cryst The results are in agreement with theoretical predictions. The contributions of both kinds of wall to constricted hysteresis loops were investigated. The characteristic constant which determines the wall thickness was measured directly. It value at 250°K is d = 165 A (+10%, −20%) for this alloy.

6299 LIMITATIONS OF THE MAGNETO-OPTIC KERR TECHNIQUE IN THE STUDY OF MICROSCOPIC MAGNETIC DOMAIN STRUCTURES.

D.Treves.

J. appl. Phys. (USA), Vol. 32, No. 3, 358-64 (March, 1961).

After considering the various factors that limit the performan of the Kerr technique in the observation of magnetic domains, it is concluded that the ellipticity caused by metallic reflection is of major importance. A detailed calculation of this effect is carried out, including the case of normal incidence. It is theoretically fou that, for microscopic observation of magnetic domains using the longitudinal Kerr effect, the contrast is practically independent of angle of incidence, and that there is an upper limit to the resolutio obtainable, which is a function of the minimum contrast needed for observation. This resolution is usually of the order of a few micr A detailed description of a Kerr instrument designed for microsco observations is included.

6300 ON ADDITIVITY OF IMPERFECTIONS AS MEANS FO DOMAIN NUCLEATION.

A.Aharoni.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 245S-246S (March, 1961).

The theoretical nucleation field is too high to explain experimental observation of domains, even if it is assumed that in a certain region the magnetocrystalline anisotropy constant K is ze In order to see to what extent the effect of such regions can be additive, a study was made of the two one-dimensional cases. In the first case, the regions of K = 0 extend periodically over the whole (infinite) material. In the second case, there are 2 such regions. The periodic case is found to yield somewhat larger nucleation field than the second case. In both cases the reduction nucleation field with respect to the perfect material is only one o of magnitude for reasonable defect size, and is slightly less than one defect of the same size.

6301 DOMAINS AND EXTREME-VALUE STATISTICS.

W.F.Brown, Jr.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 278S-279S (March, 1961).

Consider a ferromagnetic crystal at small fields. In a doma of type i (i = 1, 2, ..., n), the spontaneous magnetization lies along the ith direction of easy magnetization; the free-energy density associated with externally controlled fields is E_i, and that associa with random internal forces is ϵ_i. Postulate: at each point $\epsilon_1, \epsilon_2, \ldots, \epsilon_n$ are independent random variables, with a common distribution function F(x), and the actual orientation is that of smallest $E_i + \epsilon_i$. Let p_j be the probability that a randomly chosen point is in a domain of type j. Then

$$p_3 = \int_{-\infty}^{\infty} \{\Pi_{i\neq j}[1 - F(x - E_i)]\} F'(x - E_j)dx.$$

When $E_1 = E_2 = \ldots = 0$, the integrand is 1/n times the probability density $\Psi_n'(x)$ of the smallest value among the n ϵ_i's. Under certa conditions, the distribution function $\Psi_n(x)$ of the smallest value reduces asymptotically, for large n, to $1-\exp[-\exp \alpha_n(x-u_n)]$, whe $F(u_n) = 1/n$ and $\alpha_n = nF'(u_n)$. Under the same conditions, p_j reduc asymptotically to $\exp(-\alpha_n E_j)/\Sigma_i \exp(-\alpha_n E_i)$. This Boltzmann-type formula variously "derived", was used in an old "statistical" domain theory recently revived. Its limited success is understandable when it is interpreted as an asymptotic approximation, since n is usually only 2, 6, or 8. Use of the rigorous formula, with a reasonable form for F(x), might give better results.

6302 MEASUREMENTS OF THE DOMAIN WALL AREA—MOBILITY PRODUCT DURING SLOW FLUX REVERSALS.

R.M.Brownell and R.C.Barker.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 284S -285S (March, 1961).

Previous work (see Abstr. 10130 of 1960) has shown that the sides of slow constant-voltage hysteresis loops on polycrystalline tape-wound cores are not smooth; instead the loop sides show irregular, imperfectly reproducible variations. These variations indicate changes in the ease of motion of the so-called transition region (the outward-moving region, formed of moving domain wall in which the flux is changing). Such changes imply rearrangement of the domain walls within the transition region; and re-arrangem of the walls imply changes in their area and mobility. Measurements were made of a factor K, defined from $e_c = K(H - H_t)$, where e_c is the induced voltage-per-turn, H is the field applied at the centre of the transition region, and H_t is a threshold parameter. K is proportional to the average of the area-mobility product over the walls in the transition region. Using feedback of the induced voltage, K was measured by modulating the applied field H in such a way that the the resulting modulation in e_c was a small-amplitude square wave. The ratio of the modulation amplitudes in e_c and H gave K. This technique, which is similar in principle to Becker's, has shown that the area-mobility product varies directly with the average rate of flux change and inversely with the level of prior saturation. In the 50-50 Ni—Fe grain-oriented 2-mil tape core for which results are presented, with a prior saturating field of 10 times the coercive force H_c, as the average induced voltage was varied from 1.2 to 20 μV per turn, the mean value of K increased from 8 to 80 μV-per-turn per ampere-turn-per-metre. With the average induced voltage at 1.2, as the prior saturating field was increased from the vicinity of the coercive force to $2H_c$, K dropped from 14 to 9, then remained constant at 8 as H_s, the prior saturating field, was increased to 100 H_c. It is shown that these results are qualitatively consistent with the results from nonmodulated measurements. It is also shown that the number of active domain walls for K = 15 is of the order of 3, if each wall is assumed to be one wrap-of-tape long and if several other drastic assumptions are made.

6303 DOMAIN STRUCTURES IN IRON WHISKERS AS OBSERVED BY THE KERR METHOD.

C.A.Fowler, Jr, E.M.Fryer and D.Treves.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 296S-297S (March, 1961).

An improved magneto-optic Kerr instrument was used for observation of magnetic domains in iron whiskers undergoing a magnetization cycle with applied peak fields of 6000 Oe, parallel to the axis of the whisker. It was found that a domain structure persisted near the tip of the whiskers even under the maximum applied field. The domain configuration at fields above 2000 Oe is simple, consisting of domains magnetized perpendicular to the axis of the whisker and in the same sense around all of its lateral faces. The width of these domains decreases as the field is increased.

6304 DEMAGNETIZATION OF FERROMAGNETIC PARTICLES. F.Smith.

Brit. J. appl. Phys., Vol. 12, No. 4, 155-9 (April, 1961).

The finely divided magnetic solids, encountered in dense medium coal preparation and iron-ore beneficiation plants, show a wide variation in their residual magnetism after passage through an alternating current demagnetizer. High residual magnetism is associated with considerable oscillation of the suspended particles in the alternating magnetic field. It is shown that this behaviour cannot be unambiguously correlated with the magnetic properties of the bulked material, and a test based on settling characteristics is preferred as a means of differentiating the materials.

6305 MAGNETIC PROPERTIES OF SINGLE-DOMAIN IRON AND IRON—COBALT PARTICLES PREPARED BY BOROHYDRIDE REDUCTION.

A.L.Oppegard, F.J.Darnell and H.C.Miller.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 184S-185S (March, 1961).

Air-stable, single-domain Fe and Fe—Co particles prepared by the reaction of the metal salts with aqueous borohydride have higher coercivities and axial ratios if prepared in a magnetic field. Oxide and boride impurities are indicated by elemental analyses and lowered saturation magnetizations. Studies of coercivities and magnetization as a function of temperature, remanence ratios, and rotational hysteresis measurements indicate single-domain behaviour with coercivity controlled by shape and somewhat by crystalline anisotropy in approximate agreement with the predictions of the Jacobs--Bean "chain of spheres" model.

6306 EXCHANGE ANISOTROPY IN OXIDIZED IRON—COBALT PARTICLES. F.J.Darnell.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 186S-187S (March, 1961).

Oxidized single-domain particles of iron-cobalt were found to exhibit properties characteristic of an exchange interaction between ferromagnetic and antiferromagentic phases. After cooling in a magnetic field, the normal hysteresis loop was shifted along the magnetization axis. Rotational hysteresis and torque values show maxima with increasing field and indicate effective unidirectional fields of ~20 000 Oe. The data are consistent with an exchange model similar to that of Meiklejohn and Bean, but the exchange and antiferromagnetic anisotropy fields are larger than those found for the Co—CoO system.

6307 TEMPERATURE DEPENDENCE OF SPONTANEOUS MAGNETIZATION IN SUPERPARAMAGNETIC NICKEL.

C.R.Abeledo and P.W.Selwood.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 229S-230S (March, 1961).

The possibility of an anomalous temperature dependence of the spontaneous magnetization of superparamagnetic particles has been the subject of several investigations which are in contradiction. Nickel particles in the 30-100 A diameter range were investigated. These were prepared on silica gel supports in the manner familiar in contact catalysis. The spontaneous magnetization in these small particles is slightly but measurably lower than that of massive nickel. The calculated Curie temperature of a sample with average particle diameter of 30 A was about 565°K. It is proved impossible to confirm the large variations of Curie temperature, strongly dependent on particle size reported recently for similar preparations.

6308 SATURATION MAGNETIZATION AND SIZE OF IRON PARTICLES LESS THAN 100 A IN DIAMETER.

F E.Luborsky and P.E.Lawrence.
J. appl. Phys. (USA). Suppl. to Vol. 32, No. 3, 231S-232S (March, 1961).

Spherical iron particles were prepared by electrodeposition into mercury under conditions which produced average diameters as small as 15 A. The complete magnetization curves were obtained as a function of temperature from 4° to 300°K in fields up to 150 000 Oe. Fields of more than 50 000 Oe at 76°K were required to determine unambiguously the saturation magnetization; even higher fields were needed at higher temperatures. The saturation magnetization of larger particle size samples, obtained by aging, remained constant and corresponded to the total iron present. Particle size and size distributions were calculated from the magnetization curves by means of the Langevin function at sufficeintly high temperatures so that the samples were completely superparamagnetic. These results were compared to the particle sizes calculated from the temperature dependence of the remanence to saturation ratio. The two methods showed substantial agreement and were consistent with the properties and sizes of larger particles previously determined by direct electron microscope examination. The mean particle diameters thus determined ranged from about 15 A for the freshly deposited samples to about 60 A for the aged samples. Beyond this range the onset of stable magnetic behavior in a large fraction of the particles made the particle size calculation by these methods unsuitable.

6309 BEHAVIOR OF FERRO- OR FERRIMAGNETIC VERY FINE PARTICLES. C.J.Lin.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 233S-234S (March, 1961).

Very fine particles refer here to single-domain particles of such a size that the thermal effect on their magnetization directions is significant. If thermodynamic equilibrium is maintained during a magnetic measurement, these particles may display a quasi-paramagnetic behaviour which is usually referred to as superparamagnetism. Observation of this behaviour may depend on the apparatus used unless relaxation times are much shorter than the instrumental time constant. If it is assumed that equilibrium is achieved, the expressions for the initial susceptibility characterizing this behaviour can be derived for the standard crystalline symmetries. While the result for random particles is well known, only the aligned crystalline cases need be examined. The experiments were limited to the measurements of a number of random ferrite samples.

6310 ANGULAR VARIATION OF THE MAGNETIC PROPERTIES OF PARTIALLY ALIGNED γ-Fe_2O_3 PARTICLES. G.Bate.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 239S-240S (March, 1961).

Using a torsion balance magnetometer, measurements were made on oriented particles of γ-Fe_2O_3 covering a range of packing densities (5-6%). Microscope examination revealed that the specimens consisted essentially of long chains of particles, parallel to the orientating field, with varying degrees of cross linkages. Measurements were made as a function of the angle between the direction of the orienting field and the direction of the measuring field. The graphs of H_c (the coercivity) versus angle showed a characteristic peak at about 50° while H_r (the remanence coercivity) has its highest value at 90° to the chains and decreases with decreasing angle. Thus, the samples showed their lowest value of H_c and highest value of H_r at 90° to the chains. Torque curves for clockwise and counter-clockwise rotation were obtained as a function of applied field. From these the rotational hysteresis was calculated and gave the maximum anisotropy field at 2500 Oe for each specimen. The integral

$$\int_0^\infty W/I_s \, d(1/H)$$

was evaluated as 1.6 for the 20% specimen.

6311 COHERENT AND INCOHERENT MAGNETIZATION PROCESSES IN POWDERS.

S.Shtrikman and E.P.Wohlfarth.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 241S-242S (March, 1961).

The magnetic properties of a random assembly of uniaxial noninteracting particles are considered on the basis of two extreme mechanisms of irreversible magnetization changes: (a) coherent, and (b) completely incoherent reversals. The bulk properties are determined as weighted averages, the weighting factor $f(H_0)$ corresponding to the variation of the critical field H_0. Special integral expressions involving the bulk properties are independent of f, and may thus be used to differentiate between the mechanisms (a) and (b). Methods are suggested for determining f from the field dependence of the properties considered. An approximate criterion for neglecting particle interaction in this analysis is given.

6312 THEORETICAL MAGNETIZATION CURVES FOR PARTICLES WITH CUBIC ANISOTROPY.

C.E.Johnson, Jr and W.F.Brown, Jr.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 243S-244S (March, 1961).

Theoretical hysteresis loops were calculated for a single-crystal ferromagnetic particle with only cubic magnetocrystalline anisotropy. These calculations were carried out for various crystal orientations with the applied field. The method of computation consists of determining the magnetostatic energy over the unit sphere and then searching for minima. The curves appear similar to those resulting from shape anisotropy (Stoner—Wohlfarth) except that with certain orientations, states of stable magnetization appear which are inaccessible by traversing hysteresis loops. Averaging of the coercive force over all orientations for both positive and negative anisotropy was carried out in that range of fields where no jumps occur. A complication which causes some uncertainty is the existence, with certain particle orientations, of several stable states at which a jump might terminate. It was impossible to decide from the static energy calculation which path the magnetization follows during reversal.

6313 QUANTITATIVE DETERMINATION OF THE INTERACTION FIELDS IN AGGREGATES OF SINGLE-DOMAIN PARTICLES.

D.F.Eldridge.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 247S-249S (March, 1961).

The distribution of interaction fields in a substance composed of single domain particles may be determined from the anhysteretic magnetization characteristic of the bulk material. This characteristic as used here is the remanent induction versus applied field when, during application of the field, an alternating field decreasing slowly from well above the coercive force to zero is applied. It may be seen that when such a process is applied to an isolated single domain particle, the resulting magnetization will always be of the same sense as the applied d.c. field, even for almost negligible values of applied field. It follows that any group of independent single domain particles will also act in the same way even though there may be a distribution of coercive forces within the group: that is, for any applied d.c. field, all particles will be magnetized in one direction or the other after the application of the decreasing alternating bias field. This would imply an anhysteretic characteristic rising with infinite slope at the origin. A finite slope does not result if one merely adds a demagnetizing field, since this will only subtract from the applied field and any applied field will still produce saturation. The finite slope of the anhysteretic characteristic may be explained only by including the effects of the interaction fields. The interaction field acting on any particle is the sum of the fields from all the other particles and is determined by the geometrical arrangement of the particles independently of the applied field. Now the total d.c. field applied to any particle will be the sum of its interaction field and the external d.c. field. For any value of applied
ternal field, all particles with interaction fields smaller than the
applied external field will be magnetized in the same sense as th
applied field after the application of the alternating bias field. T
total net magnetization of a group of particles will therefore be t
cumulative distribution function of the interaction fields and will
independent of the coercive force. The actual distribution of amp
tudes of the interaction fields may therefore be readily measure
An expression is derived for the root mean square value of the in
action field at any point in an infinite aggregate of single domain
particles. This expression states that the average interaction fi
may be determined from the volumetric packing factor of the par
cles and their remanent induction. The calculated interaction fie
for an aggregate material is in close agreement with experiment
measured values.

6314 GENERAL SUPERPARAMAGNETIC BEHAVIOR OF ALIGNED ASSEMBLY OF UNIAXIALLY ANISOTROP PARTICLES.

F.G.West.

J. appl. Phys. (USA), Suppl to Vol. 32, No. 3, 249S-250S (March 1961).

The partition function which describes the thermal equilibri
behaviour of an aligned assembly of uniaxially anisotropic partic
in a field H applied along the direction of alignment is:

$$Z = 2\pi \int_0^\pi \sin\theta \exp(-a \sin^2\theta + b \cos\theta) d\theta.$$

In this expression $a = KV/kT$; and $b = \mu H/kT$, where K is the an
tropy energy density; V the particle volume; μ the particle mag
moment; k the Boltzmann factor; and T the absolute temperatur
It is shown that the tabulated function

$$y = \exp(-x^2) \int_0^x \exp(t^2) dt$$

can be used to obtain the fractional magnetization $m_{\parallel}$ along the
direction of alignment for general values of a and b. Numerica
results for $m_{\parallel}$ have been obtained for a = 0.01, 0.1, 1, 2, 5, 10,
100; and $0.01 \leq b \geq 100$. Curves of m versus b with a as a par
meter are presented. For $a < 25$ the curves are the magnetizat
curves for superparamagnetism. For a = 1 the maximum devia
from the Langevin function is about 30%. As $a \rightarrow \infty$, $m_{\parallel}$ approa
tanh b. For a = 10 the latter approximation is fairly good. The
dependence on a shows that superposition of magnetization curv
when H is normalized to b is allowable only for $a \ll 1$ and $a \gg$
Thus, when a is not known, the use of such superposition as a te
for superparamagnetism will not be valid in samples in which th
is significant particle alignment.

6315 THE VARIATION OF THE ANISOTROPIC COERCIV FORCE WITH TEMPERATURE OF HEAT TREATM OF NICKEL LAMINATIONS.

S.Rîpeanu.

Stud. Cercetari Fiz. (Roumania), Vol. 19, No. 3, 401-11 (1959).
In Roumanian.

Test pieces of nickel were cut from a nickel sheet (0.02% C
dimensions 80 × 3 × 0.3 mm so that the angle between rolling di
tion and that of cutting was at 15° intervals from 0° to 90°. Thes
were heat treated in vacuo at 100° C intervals between 300° C an
1000° C. The heating was for three hours and the specimens coo
in the furnace. A ballistic method of measurement was used fo
specimens at room and liquid air temperatures. The coercive f
of the samples before the heat treatment showed a very weak an
tropy but this was accentuated by the heat treatments at 500, 60
700° C which eliminate a large number of the stresses caused b
rolling. The character of the crystal structure changes with increasing temperature of the heat treatment and the anisotropy o
coercive force due to cold rolling was made apparent by measu
ments at liquid nitrogen temperatures. It may be that this has
related to the crystal structure observed by others by means of
X-rays.

F.E.H

6316 VARIATION WITH THICKNESS OF THE COERCIVE FIELD OF THIN LAMINATIONS AND OF FINE MAGNETIC POWDERS.

M.Rosenberg.

Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 3, 321-46 (1957).
In Roumanian.

The coercivity of laminated nickel and iron-nickel alloys (8
50% Ni) were investigated before and after annealings over the
perature range −195° to 300° C. Similar investigations were ma
powdered Fe—Co ferrites (Fe:Co in ratios 35 : 1 and 11 : 1). F
laminations of thickness from 0.35 to 0.005 mm the coercivity
not vary regularly with thickness. For normal temperatures it

ensibly proportional to λ_S/I_S where λ_S and I_S are the magnetotriction constant and intensity of magnetization, both at saturation. nnealing produced a regular variation of coercivity with thickness or all compositions. A critical thickness was found below which the oercivity increased rapidly. The variation of coercivity with temerature is generally the same for different thicknesses at constant omposition. Suggestions are made in terms of crystallite size to ccount for the observations. For the ferrite powders large coercivities were found which between 290° K and 77° K varied from 353 to 500 Oe for Fe:Co = 35 : 1 and 923 to 7300 for Fe:Co = 11 : 1. The hermal variation of coercivity is due to the change of magnetorystalline anisotropy. F.E.Hoare

6317 ANISOTROPY IN NICKEL–IRON FILMS.

D.O.Smith.

. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 70S-80S (March, 1961).

The magnetic and optical anisotropies of evaporated iron-nickel ilms deposited at an angle to the substrate normal are found to be sensitive to the rate of deposition and the orientation of the magnetzation M during deposition. It is postulated that crystallite elongation toward the vapour beam or in the direction of M occurs. Study of spatial inhomogeneities in the normal-incidence M-induced anisotropy field H_k is an aid in understanding the origin of this anisotropy and the switching behaviour of films. Small-angle dispersion of H_k s attributed to local deviation from isotropy of the isotropic tension present in films; measurements support this model. Magnitude dispersion is estimated from rotational hysteresis experiments. Large-angle dispersion of a special type has been identified wherein certain regions of a film have an easy axis perpendicular to the field present during deposition, i.e. H_k is negative in these regions. For alloy compositions within a few per cent of 83% Ni and 17% Fe, the normalized wall coercive force $h_w = H_w/H_k$ has significance beyond the defining concepts. Thus, h_w is a measure of resonance linewidth and an internal field inferred from resonance data; for $h_w > 1$, a unique "locking" phenomenon occurs. Bitter-pattern studies of quasi-static switching show that negative-H_k regions are present and that h_w is in some sense a measure of these regions. A tenative model for M-induced anisotropy which qualitatively explains both positive and negative H_k is proposed which invokes directed pairs of iron atoms and strain anisotropy arising from elongated crystallites. In nonlocking films quasi-static switching by coherent rotation is broken up by labyrinth domains consisting of alternating regions of switched and unswitched M. Propagation of these domains s postulated to be caused by dispersion in the magnitude and orienation of H_k. If a pulsed reversing field exceeds the switching hreshold of all regions of the film, a transition from labyrinth switching to coherent switching should occur, as has been observed xperimentally.

6318 EPITAXIAL GROWTH AND MAGNETIC PROPERTIES OF SINGLE CRYSTAL FILMS OF IRON, NICKEL AND PERMALLOY.

S.Chikazumi.

. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 81S-82S (March, 1961).

A number of single-crystal films of iron, nickel, and Permalloy were made epitaxially by evaporation onto (001) cleavage surfaces of NaCl and MgO. Magnetic anisotropies for the rotation of magnetzation within the plane as well as out of the plane of the film were measured. Values of the observed fourth-order anisotropy K_1 were anomalously large for Ni on NaCl and Ni on MgO, but were normal or Fe on MgO. The effects of magnetic annealing were also nvestigated for single-crystal films of Permalloy and nickel.

6319 MAGNETIC ANISOTROPIES OF NICKEL FILMS EVAPORATED AND MEASURED AT 10^{-8} mm Hg AND BELOW.

C.D.Graham Jr, and J.M.Lommel.

. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 83S-84S (March, 1961).

The magnetic anisotropies in evaporated polycrystalline nickel ilms were measured with a torque magnetometer over a range of ields from 10 to 2000 Oe. The films were deposited in a vacuum better than 10^{-8} mm Hg, and the measurements carried out in the vacuum system at pressures below 10^{-9} mm. The magnitude of the nduced uniaxial anisotropy was measured as a function of temperaure up to the Curie point of nickel (360° C), and the kinetics of the magnetic annealing process were measured from room temperature o 200° C. The anisotropy K_u decreases roughly linearly with emperature above room temperature, reaching zero near the Curie emperature. If f is the fraction of the annealing process completed t a given temperature, it is found that $1 - f = \exp(-t/\tau)^{1/3}$, and $/\tau = (1/\tau_0)\exp(-9000/RT)$.

6320 ANNEALING BEHAVIOR AND TEMPERATURE DEPENDENCE OF THE MAGNETIC PROPERTIES OF THIN PERMALLOY FILMS.

A.Segmüller.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 89S-90S (March, 1961).

Permalloy films are evaporated in a vacuum of 10^{-5} mm Hg in the presence of a magnetic field to achieve a uniaxial anisotropy. All annealing treatments and magnetic measurements are performed simultaneously in a vacuum of 10^{-8} to 10^{-7} mm Hg. In a film never heated above the deposition temperature, the temperature dependence of the uniaxial anisotropy is stronger than in bulk Permalloy, and magnetic annealing changes the anisotropy even at temperatures below 350° C. These changes are strongly dependent on whether or not the magnetization is aligned in the hard direction during cooling. During annealing above 400° C the coercive force is increased, and subsequent magnetic annealing treatments exhibit kinetics similar to those of bulk material.

6321 ROTATABLE ANISOTROPY IN THIN PERMALLOY FILMS.

R.J.Prosen, J.O.Holmen and B.E.Gran.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 91S-92S (March, 1961).

Films which possess rotatable anisotropy were observed. In these films, the easy direction of magnetization can be selected by the application of a sufficiently large magnetic field. The temperature dependence of hysteresis and resistivity were studied. Films were also examined by electron diffraction combined with partial etch techniques. It is concluded that a nickel oxide layer on the surface of the film is essential for the existence of rotatable anisotropy. Some mechanisms that may be responsible for this phenomenon are discussed.

6322 ANISOTROPY ROTATION IN THIN PERMALLOY FILMS AT ROOM TEMPERATURE.

T.Matcovich, E.Korostoff and A.Schmeckenbecher.

J. appl. Phys. (USA), Suppl to Vol. 32, No. 3, 93S-94S (March, 1961).

It was observed that the magnetic anisotropy direction of certain thin Permalloy films prepared by the thermal decomposition of nickel and iron carbonyls can be rotated through 90° at room temperature by fields less than 10 Oe. The experimental conditions under which these films were prepared suggest that this phenomenon is due to the presence of carbon. The relaxation time for the rotation of the anisotropy axis was calculated from the time dependence of the induction and found to be 10 msec. A simple model was developed which relates the anisotropy rotation to specific domain wall configurations and to the establishment of a "directional order" among interstirial carbon atoms.

6323 FREE OSCILLATIONS OF THE MAGNETIZATION IN PERMALLOY FILMS.

P.Wolf.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 95S-96S (March, 1961).

Free oscillations of the magnetization are excited in magnetic uniaxial Permalloy films by a small d.c. step pulse field with less than 0.35 nsec risetime. This field is applied perpendicularly to the magnetization and in the plane of the film. The resulting damped oscillations of the magnetization are detected by a sampling oscilloscope and investigated between 500 and 1200 Mc/s. The eigenfrequency is determined by a d.c. field parallel to the magnetization and by the orientation of the easy axis. The eigenfrequencies agree reasonably with the ferromagnetic resonance frequencies of the same films. The damping constants λ evaluated from the decay time of the free oscillations and from the linewidth of ferromagnetic resonance also agree fairly well and are in the range from 100 to 300 Mc/s. The experimental results are analysed by means of the Landau–Lifshitz equation.

6324 SOME PROPERTIES OF UNIAXIAL PERMALLOY FILMS PREPARED BY CATHODIC SPUTTERING.

M.H.Francombe and A.J.Noreika.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 97S-98S (March, 1961).

A preliminary study has been made of the magnetic and structural properties of Permalloy films prepared by cathodic sputtering. Films of the nonmagnetostrictive Ni : Fe : :81 : 19 composition were deposited by sputtering in argon both from solid Permalloy cathodes and from copper cathodes which had previously been electroplated with Permalloy. Using a gas pressure of 100 μ, with the electrode potential 3500 V and a discharge current 150 mA, a deposition rate of about 15 A/sec is obtained. When deposited in an applied field of 20 Oe, the films display uniaxial anisotropy with $H_c \cong 2.5$ Oe and $H_k/H_c \cong 1.5$. An evaluation of the uniformity of film thickness, reproducibility of coercive force, and alignment of the magnetic easy axis indicates that films prepared by this method would be suitable for use in planar memory matrices.

6325 MAGNETIC THIN FILMS PREPARED BY SPUTTERING.

E.Kay.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 99S-101S (March, 1961).

Experimental study of magnetic thin films prepared by sputtering in a glow discharge environment showed that crystal structure and chemical purity, as well as particle size and surface morphology, can be controlled. Different physical properties, including B-H characteristics, can be reproducibily obtained by the location of the collecting substrate with respect to the characteristic zones of the glow discharge; e.g. Crookes dark space, negative glow, positive column, etc. This is the result of variations in deposition rate and energy distribution of the material arriving at the substrate, as well as variations in intensity of electron bombardment and the consequent temperature of the substrate. Typical results on nickel and iron films are reported. In contrast to several reports in the literature, ferromagnetic f.c.c. nickel films were deposited directly by sputtering. Completely unoriented, polycrystalline b.c.c. Fe films were prepared in which $B_r/B_s \sim 1$, $H_c \sim 250$ Oe, and $B_r \sim 20\,000$ Oe; i.e. the magnetic characteristics were quite different from those obtained by high-vacuum evaporation.

6326 SPIRAL WALLS IN THIN MAGNETIC FILMS.

H.W.Fuller, H.Rubinstein and D.L.Sullivan.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 286S-287S (March, 1961).

Dense concentrations of walls were previously observed to appear in very thin magnetic films with the application of an a.c. demagnetizing field. Other observations showed roughly circular concentric walls around barely discernible imperfections. Particularly clear powder patterns of such walls that were obtained on the thin end of a Permalloy film of tapered thickness are presented. The patterns allow the deduction of the detailed magnetization distribution which takes the form of a pair of antiparallel domains that spiral in toward the central imperfection. A mechanism for the formation of spiral walls is presented, together with confirming experimental evidence. The experiments establish the nature of the central imperfection as a region of abnormally high uniaxial anisotropy where the magnetization is constrained to lie in one direction along the easy axis while the magnetization of the surrounding regions of the film can be rotated with an applied field.

6327 THIN-FILM SWITCHING IN THE HARD DIRECTION BY WALL MOTION.

R.J.Spain and H.Rubinstein.

J. appl Phys. (USA), Suppl. to Vol. 32, No. 3, 288S-289S (March, 1961).

Hysteresis loops in thin films observed with the driving field applied perpendicular to the easy axis often exhibit appreciable squareness of the loop, suggesting the existence of another easy axis along what is presumed to be the hard direction. Measurement of the anisotropy in such films indicates a uniaxial anisotropy with the hard axis along the direction in which the second square loop is found. Observing magnetization reversal in these specimens by the Kerr effect, one notices wall motion which is again characteristic of a second easy axis perpendicular to the first. The use of Bitter powder patterns shows this wall activity with sufficient detail to support the theory that the occurrence of an apparent second easy axis can be normal behaviour in a film with uniaxial anisotropy. If the characteristics of the film are such as to cause the magnetization to return to a multidomain state when a saturating field is applied along a hard direction and then removed, this direction can be expected to exhibit properties normally associated with an easy axis. The directions which seem to define the hardest axes are then found at angles slightly greater and less than 90° from the real easy axis. The paper describes the theory behind such behaviour and the experimental observations which it explains.

6328 MAGNETORESISTIVE MEASUREMENTS ON DOMAIN ROTATION AND WALL DEVELOPMENT IN Ni—Fe ALLOY FILMS.

F.G.West.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 290S-292S (March, 1961).

In low saturating magnetic field, the magnetoresistive effect in a polycrystalline ferromagnet is described by the relation $\Delta\rho/\Delta\rho_0 = \cos^2\alpha$ where $\Delta\rho$ is the resistivity change which occurs when the saturation magnetization M_S is oriented first normal then at an angle α to the electric current i. The maximum change $\Delta\rho_0$ is characteristic of the material. The uniform rotation model of a uniaxially anisotropic film in a transverse magnetic field $H_\perp$ leads to a dependence of $\Delta\rho$ on $H_\perp$ of the form $\Delta\rho/\Delta\rho_0 = h_\perp{}^2$ when i is normal to the anisotropy axis (K axis) and of the form $\Delta\rho/\Delta\rho_0 = 1 - h_\perp{}^2$ when i is parallel to the K axis. In these expressions $h_\perp$ is the ratio of $H_\perp$ to H_K, where $H_K = 2K/M_S$, and K is the anisotropy energy constant. The present paper treats the transverse magnetization process in Ni—Fe alloy films on the basis of a simple model in which the K axes in local regions of the film are dispersed in direction about an average $\langle K \rangle$ axis. For a single numerical value of the dispersion angle β the transverse magnetoresistive behaviour is described by $\Delta\rho/\Delta\rho_0 = (h_\perp + \beta)^2$ when i is normal to $\langle K \rangle$ and $\Delta\rho/\Delta\rho_0 = 1 - (h_\perp + \beta)^2$ when i is parallel to $\langle K \rangle$. The model also requires that the ratio of transverse remanent magnetization to M_S be $\sin\beta$. These predictions are experimentally verified for films which gave values of β from 0.1 to 0.3 (6° to 18°), and show the applicability of the Stoner—Wohlfarth theory to domain rotation.

6329 MAGNETORESISTANCE AND MAGNETIC SWITCHING IN PERMALLOY FILMS.

R.L.Coren and H.J.Juretschke.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 292S-293S (March, 1961).

Magnetoresistance measurements were used to study the magnetic properties of Permalloy films. Resistivities parallel and transverse to the current were measured simultaneously as the applied magnetic field was varied in magnitude or direction in the film plane. The results are discussed in terms of a representation in which the resistivity components are regarded as Cartesian coordinates. This representation is independent of the current direction relative to any magnetically preferred orientations in the film. The statistical, domain wall, switching model of Conger and Essig is extended to include the situation in which the field and easy magnetic axis are not parallel, and a switching profile is constructed which gives a unified representation of the domain wall an coherent rotational switching response of a uniaxial film to an applied field. The incidence of moving domain walls under certain field conditions is discussed with the help of this profile, and it is shown that the magnetoresistance curves may be understood in terms of the magnetic changes.

6330 NUCLEATION PROCESSES IN THIN PERMALLOY FILMS.

S.Methfessel, S.Middelhoek and H.Thomas.

J. appl. Phys. (USA), Suppl. to Vol. 32,No. 3, 294S-295S (March, 1961).

Normally, wall motion in thin Permalloy films starts from nuclei of reversed magnetization at the edges of the film, which ar created by the demagnetizing field. Therefore, for the investigati of nucleation processes inside the film, the edge effects have to be suppressed. This has been done by two methods: The first is base on the use of inhomogeneous driving fields, and the second on the formation of a high coercive force barrier between the edges and the central area of the film. This barrier prevents the edge domai from moving into the central area. Depending on the maximum amplitude of the driving field, different modes of nucleation are possible leading to different hysteresis loops. Since the domain nucleation must be attributed to a rotational process, the starting field is measured as a function of the uniaxial anisotropy field, which is changed by bending the film. The results agree with the dependence found by Preisach for Permalloy wires under stress.

6331 CALCULATION OF MAGNETOSTRICTION IN STRONG MAGNETIC FIELDS.

G.P.D'Yakov and A.A.Kozlov.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 3, 576 (1958). In Russian.

The law of magnetostriction in the region approaching technical saturation of a polycrystalline material with isotropic magnetostriction coefficients is derived retaining terms in the applied field H, up to H^{-3}. The new law is of the form $\lambda = \lambda_S(1 - BH^{-1} - cH^{-3})$ and the physical significance of the consta c is discussed. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 3, 190 (1958)]. R.Parke

6332 EXPERIMENTAL g' AND g VALUES OF Fe, Co, Ni, AND THEIR ALLOYS.

A.J.P.Meyer and G.Asch.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 330S-333S (March, 1961).

The magnetomechanical ratio g' and the spectroscopic factor g were measured on same samples of iron and nickel. The g factors were also measured for some Fe—Ni, Fe—Co, Co—Ni, alloys. The experimental values of g and g' are used to check Kittel—Van Vleck relations whose exact form $(1/g) + (1/g') = 1$ appears well satisfied. It is shown that the effective magnetomechanical ratio g'_{eff} of an alloy which is given by the quotient of the total magnetic moment to the total angular momentum of the system, converts itself by mean of the relation $(1/g) + (1/g') = 1$ to the formula of Tsuya and Wangsness, which gives the effective splitting factor g_{eff} of a two-sublattice system. The calculated curves of g_{eff} agree with the expenental points for the Fe–Ni, Fe–Co, Co–Ni alloys. Using the easured values of g and g' calculations are made of the mean spin oment contribution of the ferromagnetics with a mean electronic mber higher as 26.8 which crystallize in f.c.c. or hexagonal ructures: the mean spin moment decreases linearly by increa-ng electronic number with a slope of $-1.5\ \mu_B$/electron.

6333 TEMPERATURE DEPENDENCE OF MAGNETOSTRICTION AND ANISOTROPY IN MnBi.

A.Albert and W.J.Carr, Jr.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 201S-202S (March, 61).

Measurements were made of the magnetostriction and isotropy in oriented polycrystals of MnBi at various temperatures etween 77 and 300°K. The magnetostriction constants in a four-nstant expression have been evaluated as a function of temperature, d the first three anisotropy constants also have been estimated. least at the lower temperatures, it is found that all three-con-ants are necessary to fit the anisotropy data.

6334 ANISOTROPY AND MAGNETOSTRICTION IN MAGNETIC OXIDES.

J.C.Slonczewski.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 253S-263S (March, 61).

Recent theories of the anisotropy and magnetostriction due to the esence of Co^{2+} in spinel ferrites are reviewed and new work on the fects of Fe^{2+} is presented. The effects of these ions are great cause the orbital angular momentum is not fully quenched by the ystal field. In the case of Co^{2+}, the orbital moment of the ground ate is coupled strongly to the trigonal axis of the crystal field. The ry large anisotropy and magnetostriction arise from spin–orbit upling in first order. The theory is found to account for many of e effects of cobalt–iron ferrite and cobalt–manganese ferrite at gher temperatures. The contribution of Fe^{2+} to these effects is ss extreme but still striking. Here the orbital moment is more arly quenched but the spin is still coupled strongly to the trigonal is. The coupling gives rise to cubic anisotropy in second order proximation. This term appears to account for the large compo-tional dependence of anisotropy in manganese-rich manganese–on ferrite. A crystal-field calculation of the orthorhombic distor-on of the low-temperature form of magnetite is found to be consis-nt with observations at about 80° K, assuming a high degree of rwey ordering. However, the anisotropy calculated on the same sumption is found to be inconsistent with experiment. It is conclu-d that the one-ion crystal-field theory is largely applicable to the fects of Co^{2+} and Fe^{2+} in ferrites. However, it does not work when e concentration of Fe^{2+} is high.

6335 FREQUENCY DEPENDENCE OF ULTRASONIC WAVE ATTENUATION IN ARMCO IRON AND LOW-CARBON TEEL.

U.M.Martius and W.J.Bratina.

appl. Phys (USA), Suppl. to Vol. 32, No. 3, 280S-281S (March, 61).

The ultrasonic wave attenuation in Armco iron and low-carbon eel was measured versus increasing and decreasing external agnetic field strength (0-400 Oe) at frequencies between 1 and Mc/s. The magnetic component of attenuation was found to increase ith frequency. The structure sensitivity of the magnetic loss echanism was studied by changing the dislocation density. A con-nuous decrease of attenuation with increasing field is characteristic r annealed material, and a pronounced maximum followed by a ecrease for deformed material. The results are discussed on the sis of models of structure-sensitive magnetic properties advanced Neel and recent work by Kersten. These models are unable to plain consistently all experimental observations. The possibility loss processes within stationary domain walls was considered.

6336 HIGH-TEMPERATURE MAGNETIC LAG IN IRON–NICKEL ALLOYS.

D.Gerstner and E.Kneller.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 364S-365S arch, 1961).

The kinetics of the lag of permeability (disaccommodation), curring in quenched Fe–Ni alloys with 45-85% Ni at temperatures tween 300° C and the Curie temperature, were investigated. The fect could be analysed as caused by at least two different diffusion ocesses: (1) formation of short-range directional order according Neel and Taniguchi–Yamamoto, and (2) formation of a quasi-otropic structural change, which is probably formation of Ni_3Fe ng-range order. In principle, the same lag behaviour was found 5-79 molybdenum Permalloy.

6337 THE EFFECT OF CORE CURRENT ON MAGNETIC MATERIALS.

J.B.Dinklage.

Proc. Iowa Acad. Sci. (USA), Vol. 67, 443-8 (1960).

The effect on the hysteresis of sending a direct current through the core of a ferromagnetic torroid is described. A model describing this effect is then related to the magnetostrictive properties of the material. An easy method for determining the "polarity" of the magnetostrictive properties of a material is presented.

6338 THE MECHANISM OF THE HETEROGENEOUS DECOMPOSITION OF Fe–Cu–Ni PERMANENT MAGNET ALLOYS.

K.Schüler.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960). p. 140-7.

The effects of thermal and mechanical treatment on the magnetic properties were investigated by an analysis of the rotational hysteresis curves which give information about the shape anisotropy of the precipitate particles. See also Müller and Schüler, Wissenschaftliche Zeitschrift der Hochschule für Verkehrswesen Dresden, Vol. 7, No. 1, p. 27-91 (1959).

E.P.Wohlfarth

6339 TEXTURE AND LOSS PROBLEM IN SiFe.

D.Ganz.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 59-65. In German.

The losses of thinly laminated toroids of SiFe with different texture and domain structure are compared at the frequency of 1 kc/s. Specimens with large magnetic domains exhibit enhanced eddy-current losses.

R.Parker

6340 THE STATE AND MAGNETIC PROPERTIES OF AN ALLOY WITH 50% Ni AND 50% Fe.

G.Rassmann and H.Wich.

Ferromagnetism Working Party, Berlin, 1959 (see Abstr. 18171 of 1960) p. 181-9. In German.

The effect of tempering and of magnetic fields on Ni–Fe alloys were investigated in the temperature range 400° to 600° C. The alloys were either cube orientated or recrystallization aggregates. Primarily, alloys with 50% Ni and 50% Fe were investigated. The rectangularity of the hysteresis loop of cube orientated alloys is destroyed on tempering at 450° and the coercivity is increased. In contrast, if the tempering is carried out in a magnetic field the maximum permeability (μ_{max}) is increased from 15 000 to 200 000 while the initial permeability (μ_0) drops from 2500 to 250. In recrystallization aggregates μ_{max} shows a strong and μ_0 a slight dependence on the tempering temperature (T). Especially high values for μ_{max}(150 000) are obtained for T = 500°. The maximum μ_0 attained (9500) exceeds that expected on Kersten's theory. In the presence of a magnetic field, μ_{max} decreases rapidly with T between 510° and 420° while μ_0 increases appreciably below 450°. The behaviour of μ_{max} is similar to that obtained in the absence of a field but the decrease is retarded due to the field. A value of 20 000 for μ_0 could be obtained in an experiment in which the specimens were tempered for 4 hours at 450°. Alloys with a Ni-content of from 43 to 65% (Rest Fe) were investigated to clarify the role of Ni. In cube-orientated structures the ratio $B_r : B_S$ decreases with increasing Ni-content. Magnetic field treatment increases the ratio to 0.95 to 0.98. For T = 450°, μ_0 increases with Ni-content and reaches a maximum just above 50% Ni. Above 55% Ni it is less than the value obtained if tempered at 500°. μ_0 for alloys with 43% Ni is the same for T = 450° and 500°. Similarly, in recrystallization aggregates μ_0 for a Ni-content of 43% Ni is the same for the two values of T, but the difference in μ_0 for the two temperatures for other Ni-contents attains a maximum at 50% Ni. Thus, besides the familiar maximum in μ_0 at 78% Ni, a second maximum at 50% Ni appears. No influence of a magnetic field treatment was observed in alloys with 43% Ni but in alloys with 50% and more Ni, μ_0 increases due to such treatment. The behaviour of μ_{max} is similar to that of μ_0. In cube oriented as well as recrystallization aggregates the effect of tension on μ_0 is similar to that of the duration of tempering. In cube orientated alloys with 50% Ni μ_0 decreases monotonically with tension; in recrystallization aggregates of the same composition it increases. However, in the latter alloys with 65% Ni μ_0 passes through a maximum as the tension is increased.

D.S.Parasnis

6341 DEVELOPMENT OF ELONGATED PARTICLE MAGNETS.

F.E.Luborsky.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 171S-183S (March, 1961).

The development of permanent magnet materials is briefly reviewed. The present status of fine-particle magnets is discussed from the viewpoint of our present understanding and lack of understanding of their behaviour. The present methods of preparation and the various theoretical descriptions of the properties of elongated particles are reviewed. New work is presented relating the parameters of preparation to the resulting diameter of the elongated particles prepared by electrolysis into mercury. Rotational hysteresis, coercive force, and coercive force as a function of orientation are reported for particle diameters from 130 A to 305 A. Their behaviour is compared to various theoretical descriptions and found to correspond to a noncoherent magnetization reversal mechanism most similar to the chain-of-spheres fanning model rather than the curling, buckling or coherent rotation models. Iron and iron-cobalt alloy particle magnets are described with maximum energy products up to 4.3 and 6.5 million gauss oersted respectively.

6342 MAGNETIC ANNEALING OF "TICONAL" G MAGNET STEEL. H.Zijlstra.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 194S-196S (March, 1961).

A study was made of magnetic anisotropy and interparticle distance in "Ticonal" G (a dispersion-hardening permanent-magnet alloy) when subjected to heat treatment in a magnetic field. The experimental results agree with a theoretical model in which the precipitate particles are idealized to prolate spheriods which decrease their interfacial free energy by coarsening and their magnetostatic free energy by elongation. It is concluded that the response to thermomagnetic treatment increases with the ratio between the magnetostatic free energy and the interfacial free energy. The interface tension of "Ticonal" G is found to be extremely low, of the order of 1 erg cm^{-2} at the annealing temperature.

6343 SOME INVESTIGATIONS ON IRON—COBALT PERMANENT MAGNET ALLOYS OF THE VICALLOY II TYPE.

W.Baran, W.Breuer, H.Fahlenbrach and K.Janssen.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 199S-200S (March, 1961).

A permanent magnet alloy composed of 52% Co, 8% V, 4% Cr, balance Fe was subjected to severe cold forming by drawing or rolling to produce a reduction in cross-sectional area of over 90%, and to subsequent heat treatments at temperatures varying between 20 and 700°C, after which the following properties were measured: magnetic saturation as a function of temperature in the range from −200 to +700°C; coercive force as a function of temperature in the range from −200 to +400°C; remanence; torque in the magnetic field, anisotropy energy, and longitudinal magnetostriction as a function of temperature in the range from +20 to +400°C. Vickers hardness, ultimate tensile strength, Young's modulus, and coefficient of expansion were also determined in some cases and electron micrographs of the structure taken. The permanent magnet alloy tested consists of a fine two-phase structure, the body-centred cubic α phase alone being ferromagnetic above room temperature, while the second phase becomes ferromagnetic only at temperatures below room temperature. Magnetizing and demagnetizing of this alloy, too, is brought about chiefly by domain rotation. Basically, permanent magnet characteristics are not produced by crystal anisotropy or anisotropy of directional order but by a uniaxial anisotropy which may be either a shape or a strain anisotropy. The measured magnetic properties can be more easily explained by an anisotropy of internal stresses which in one model concept is produced by the process of $\alpha-\gamma$ transformation because of the clearcut textures of both components. There are also indications that the mutual transformation of the two structure components is coincident with noticeable shifts in chemical composition or order, particularly in the γ phase.

EFFECT OF THERMOMAGNETIC TREATMENT ON MAGNETIC PROPERTIES OF SOME ALLOYS. See Abstr. 6533

METALLURGY AND MAGNETIC PROPERTIES OF AN Fe—Co—V ALLOY. See Abstr. 6523

CUBE TEXTURE IN ULTRATHIN MOLYBDENUM PERMALLOY TAPE. See Abstr. 6527

6344 HIGH-TEMPERATURE STABILITY OF MAGNETIC MATERIALS. N.Pavlik.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 372S-373S (March, 1961).

Most high Curie temperature magnetic materials show a significant irreversible change in magnetic properties as a result of exposure to 500°C and return to room temperature. A possible explanation of the cause of some of these changes, especially in the high Curie temperature alloys, is presented. Investigations showed that cobalt-iron alloys containing from 27 to 43% cobalt can be stable magnetically up to at least 600°C. The 49% cobalt alloy can be stable up to at least 500°C However, this temperature stability is dependent upon several impo ant considerations. One of these is the geometry of the test system For example, a tape-wound toroidal core tested at elevated tempera tures in air becomes severely oxidized — this oxidation or the strains induced by it adversely affect the magnetic properties. However, when the same core is tested in a neutral atmosphere, the strains due to oxidation are minimized and the magnetic properties remain stable. Data are presented comparing tests on toroids with and without neutral atmospheres, both oriented and nonoriented allo containing 27, 35, 43, and 49% cobalt. Finally all results are compared with square punchings relating the differences in high-temper ture stability of the magnetic properties due to geomagnetic configu rations.

6345 INELASTIC MAGNETIC SCATTERING OF SLOW NEUTRONS IN METALLIC CERIUM. B.M.Khabibullin.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 825-8 (Dec., 1960). In Russian.

The Born approximation is used to find the differential cross-section for magnetic inelastic scattering of thermal neutrons in the close-packed cubic lattice of cerium in the case of atomic transitions between Stark levels formed in an internal crystal field. The calculated differential cross-section is shown to be of the orde of the cross-section for elastic magnetic scattering. The angular dependence of the calculated cross-section has the same symmetry as the crystal field.
A.Tybulewic

6346 NEUTRON DIFFRACTION BY HELICAL SPIN STRUCTURES. W.C.Koehler.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 20S-21S (March, 1961

This is the summary of a paper which discussed neutron diffraction techniques as applied to helical type and related spin structures, and illustrated these techniques with results from recent investigations on $MnAu_2$ and metallic holmium.

6347 NEUTRON DIFFRACTION INVESTIGATION OF MAGNETIC ORDERING IN DYSPROSIUM.

M.K.Wilkinson, W.C.Koehler, E.O.Wollan and J.W.Cable.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 48S-49S (March, 196

Neutron diffraction measurements on a single crystal of dysprosium show that the magnetic structure in the antiferromagne region between 179° and 87°K closely resembles a helical-type arrangement of the atomic moments. In this arrangement the moments within a hexagonal layer are aligned parallel and point in a direction perpendicular to the c axis of the crystal. The moment direction in adjacent layers is rotated by a specific angle which is dependent on the temperature of the sample. A slight modification of this structure exists below about 140°K, and a transition to ferromagnetism occurs at 87°K.

6348 NEUTRON DIFFRACTION STUDY OF METALLIC ERBIUM.

J.W.Cable, E.O.Wollan, W.C.Koehler and M.K.Wilkinson.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 49S-50S (March, 1961

Neutron diffraction measurements bere made on erbium single crystals in the temperature range 298°-4.2°K. The material is antiferromagnetic below 80°K and ferromagnetic below 20°K. In the antiferromagnetic region, the magnetic scattering consists of satellite reflections corresponding to a modulation of the magnetic scattering amplitude along the c axis. The spacing and intensity distribution of these satellites show two distinct subregion of antiferromagnetism. In the upper region, between 80° and 52°K, the data suggest a sinusoidal modulation of the magnitude of the c-axis component of magnetic moment with a period of 3.5 c_0. Between 52° and 20°K the wavelength of the modulation varies continuously from 3.5 c_0 to 4.0 c_0. In addition, there is a squaring up of the modulation and a simultaneous ordering of the component of the moment normal to the c axis. Below 20°K the material is basically ferromagnetic with a moment of 7.2 μ_B directed parallel to the c axis.

MAGNETOSTRICTION FERRITES AS ELECTROACOUSTIC TRANSDUCER MATERIALS. See Abstr. 5323

GENERATION OF MICROWAVE ELECTROMAGNETIC RADIATION IN MAGNETIC MATERIALS. See Abstr. 5577

6349 CLASSICAL THEORY OF THE GROUND SPIN STATE IN SPINELS.

T.A.Kaplan, K.Dwight, D.Lyons and N.Menyuk.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 13S-20S (March, 1961)

An investigation of the ground state of the classical Heisenberg

change energy in spinels has led to several new results. By
eans of a recent generalization of the method of Luttinger and
sza, the ground state in part of the exchange parameter space
fined by nearest neighbour AB and BB interactions for
tragonally distorted spinels is obtained. The regions in this space
ere the Néel and Yafet—Kittel configurations minimize the energy
e much smaller than predicted by the Yafet—Kittel six-sublattice
eory. Outside of these regions, there exists a domain where the
ound state is an antiferromagnetic spiral similar to those
cently introduced in the literature. In still other regions, the
ound state is a new type of spiral which is ferrimagnetic. An
vestigation of a parameter region including cubic spinels shows
at such a ferrimagnetic spiral yields an appreciably lower energy
an that given by the Yafet—Kittel model and is locally stable up to
specified ratio of BB to AB interactions. The generalized
uttinger—Tisza method shows it to be the best possible ferri-
agnetic spiral up to and beyond the point of instability, but fails
prove it to be the ground state. An examination of small devia-
ons at the point of instability indicates the existence of spin
nfigurations much more complex than the magnetic spirals
oposed here.

6350 PREPARATION AND PROPERTIES OF THIN FERRITE FILMS.

.Banks, N.H.Riederman, H.W.Schleuning and L.M.Silber.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 44S-45S (March, 1961).

Thin films of ferrites, of the order of 1000 A thickness, were
epared by vacuum evaporation of the metals, and subsequent high-
mperature oxidation. Films of iron, nickel, cobalt, magnesium,
d copper ferrites, mixed ferrites, and mixed ferrite-aluminates,
well as yttrium iron garnet, were prepared. X-ray powder
ffractometry indicates that the ferrite films are single-phase
inels, while the garnet shows the garnet structure. In many
spects, the properties of the films are the same as those of bulk
rrites of similar composition. The resistivity of the films can be
ntrolled by proper oxidizing procedures. X-band magnetic reso-
nce measurements indicate that the saturation magnetization of
e films are comparable to those of the corresponding bulk ferrites,
ough the films show larger resonance linewidths. It was possible
prepare magnesium ferrite films with magnetizations from 2200 G
less than 500 G by proper annealing and quenching. The possible
dvantages of thin films are that they allow optical studies of the
aterial by transmission, and should permit determination of
agnetic exchange constants through observation of spin wave reso-
nces.

6351 FERRITE THIN FILMS.

H.P.Lemaire and W.J.Croft.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 46S-47S (March, 1961).

Thin films of ferrites of various compositions were prepared.
wo methods were developed, both involving a spray technique
hereby hot suspensions of hydroxides are directed onto a heated
bstrate. The ferrite films are formed essentially through a co-
ecipitation mechanism. X-ray diffraction has shown that the films
ve a cubic spinel structure. Various compositions were attained;
agnetite, nickel ferrous ferrite, a magnetite—zinc ferrite series,
d other mixed ferrites. Coercive force measurements were made
om hysteresis loops obtained on a 1000 cycle loop tracer. The
lms are magnetically isotropic and have a high squareness ratio.
ilm thicknesses were varied from a few hundred A to about 1 μ.
elative film thicknesses were estimated by using a spectrophoto-
etric technique. For a fixed composition, coercive force decreases
ith increasing thickness. Magnetite films had coercive forces
rying from 170 to 300 Oe depending on thickness. A nickel ferrous
rrite series had coercive forces varying from 225 Oe for thick
lms to 400 Oe for a very thin one. Coercive force measurements
e related to composition variations in a series of zinc ferrous
rrite films.

6252 TRIANGULAR MOMENT ARRANGEMENTS IN MANGANESE-IRON SPINELS. V.L.Moruzzi.

appl. Phys. (USA), Suppl to Vol. 32, No. 3, 59S-61S (March, 1961).

The anomalously low magnetic moments for $Mn_xFe_{3-x}O_4$ spinels
ith $1 < x \leq 3$ are qualitatively explained by a Yafet—Kittel triangular
oment arrangement. Values of β, n, and α are calculated from
easurements of magnetic moment, high field susceptibility, and
urie temperature. The measurements on Mn_3O_4 yield a moment of
73 Bohr magnetons and a susceptibility of 3.5×10^{-4} G/Oe. An
trapolated anisotropy field of 150 kOe is found. Transitions from
e triangular state to a Neel-type arrangement are found to occur
r $x = 1.25$, $x = 1.55$, and $x = 1.80$. For Mn_3O_4, $\alpha\beta$ values suggest
at the vanishing of the spontaneous magnetization at 42° K
presents a transition to a paramagnetic—antiferromagnetic state.

6353 TEMPERATURE DEPENDENCE OF THE SPIN-WAVE SPECTRUM OF YTTRIUM IRON GARNET.

R.C.LeCraw and L.R.Walker.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 167S-168S (March, 1961).

The temperature dependence of the exchange constant D in the equation of the spin-wave spectrum was measured at 4.2° K-500° K in single crystals of very pure yttrium iron garnet. The results are compared, with good agreement up to 325° K, with predictions based on an extension of the random phase approximation to a ferrimagnet.

6354 ELONGATED IRON—COBALT FERRITE: A NEW, LIGHTWEIGHT, PERMANENT MAGNET MATERIAL.

R.B.Falk and G.D.Hooper.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 190S-191S (March, 1961).

The preparation of fine particles of elongated iron--cobalt ferrite is described. Coercive forces ranging from 2400 Oe, for partices having 57% Fe, 31% Co, and 12% O, to over 7000 Oe, for particles having 47% Fe, 26% Co, and 17% O, were measured at −196° C. Compacts prepared from particles with the composition 57% Fe, 31% Co, and 12% O had the following magnetic properties when measured at 25° C: $B_r = 6200$ gauss, $H_c = 1550$ Oe, and (BH) max = 4.0×10^6 gauss Oe. The compacts have a physical density of 3.7 g/cm^3, and are stable magnetically at temperatures up to 100° C. Magnets exhibit a reversible decrease in remanence of less than 1% over the temperature range of −196° to +50° C. The observed magnetic properties can be accounted for in terms of a cobalt ferrite shell in exchange contact with its elongated iron—cobalt core.

6355 PREPARATION, GROWTH, AND STUDY OF ULTRA-FINE FERRITE PARTICLES.

W.J.Schuele and V.D.Deetscreek.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 235S-236S (March, 1961).

Ultrafine ferrite particles were prepared by a chemical precipitation process below 100° C in an aqueous medium. The resulting materials were grown hydrothermally at moderate temperatures for extended periods of time. Samples were removed at various times during the growing process and their magnetic and physical properties determined. Coercive forces varied from zero to about 800 Oe at room temperature for some hydrothermally grown cobalt ferrites. At liquid nitrogen temperature coercive forces to 10 000 Oe were measured. Crystallite size measurements were made by X-ray line broadening. An apparatus to measure hysteresis loops in pulsed fields was constructed and used for measuring magnetic properties of samples difficult to saturate, i.e., cobalt ferrite samples at −196° C. Good agreement was obtained between pulsed fields and d.c. measurements where samples could be measured by both systems.

6356 FINE-GRAINED FERRITES. I. NICKEL FERRITE.

W.W.Malinofsky and R.W.Babbitt.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 237S-238S (March, 1961).

A process was developed for preparing dense nickel ferrite bodies composed of grains small enough to remain single domains by combining two techniques, flame-spraying and hot-pressing, and investigating the effect of varying the parameters in each of these. Powder as fine as 0.02 micron was prepared of single phase nickel ferrite, which was subsequently densified by hot-pressing while maintaining the crystallite size as small as 0.06 micron (below the critical size for multidomains). The effect on the dispersion of the complex permeability as the ferrite is annealed through the critical size is discussed. Properties measured included μ' and μ'' (to 3800 Mc/s), B_{max}, B_{rem}, and H_c, as well as microwave properties. Of practical interest was an improvement in the temperature coefficient of initial permeability over conventionally prepared ferrite, and good linearity in the main resonance loss at high power levels at X-band. X-ray diffraction determinations of crystalline phases and crystallite sizes are given, along with measurements of apparent density. Theoretical considerations indicate domain rotation to be the mechanism responsible for the resonances observed at high frequencies.

6357 MAGNETIC DOMAIN PATTERNS ON BARIUM FERRITES. M.Nagakura and T.Yamaguchi.

Res. Rep. Fac. Engng Meiji Univ. (Japan), No. 13, 22-6 (1959—1).

Domain patterns on large crystals of the anisotropic barium ferrites were observed microscopically with a colloidal solution of fine iron oxide particles. Domain patterns on the hexagonal plane have complicated configurations such as a maze pattern, a flower pattern, etc. The distance between the domain walls observed on the hexagonal plane is about few microns, assumed superficial. On both faces, the behaviour of the powder patterns was observed with the magnetizing field in the direction of the hexagonal axis.

6358 THE MEASUREMENT OF LONG-DURATION MAGNETIC REMANENCE AFTEREFFECT IN FERRITES.

F.Pliquett.

Ann. Phys. (Germany), Vol. 7, No. 3-4, 216-19 (1961). In German.

A magnetometer arrangement, compensating for stray fields to the extent that changes in remanence of a ferrite specimen over a period of some hours may be measured, is described. A brief discussion of results for a NiZn ferrite is given. A.J.Manuel

6359 THE EFFECT OF HEAT TREATMENT ON MAGNETIC PROPERTIES OF NICKEL—ZINC FERRITES.

N.I.Lapkin, N.G.Bukhvostova and G.A.Falaleev.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 521-6 (Oct., 1960). In Russian.

Reports the effect of the annealing and sintering temperatures on the initial permeability, loss-angle tangent, coercive force, remanent induction and the Curie point of ferrites consisting of 66% Fe_2O_3, 12% NiO and 22% ZnO (all these percentages are proportions by weight). Optimum conditions were found for production of ferrite cores of pulse transformers. A.Tybulewicz

6360 A FURTHER EXPLANATION OF THE SHAPE OF THE HYSTERESIS LOOP OF "SQUARE LOOP" FERRITES.

J.E.Knowles.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 225-29 (Feb., 1961).

In an earlier paper it was assumed that the individual grains of a "square loop" ferrite have rectangular hysteresis loops. This hypothesis has now been given a theoretical justification, based on a model due to Néel. It was also possible to estimate the number of times (14) that the energy of a typical domain wall passed through a minimum in the course of a magnetization reversal.

6361 VARIATION OF MAGNETIC PROPERTIES OF MIXED FERRITES, Cu + Ni, AS A FUNCTION OF THE RATIO OF COPPER FERRITE TO NICKEL FERRITE.

E.Lăbuşcă and F.Constantinescu.

Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 3, 347-57 (1957). In Roumanian.

Starting from a nickel ferrite, of the type $NiFe_2O_4.ZnFe_2O_4$, characterized by low losses, and a copper ferrite of type $CuFe_2O_4.ZnFe_2O_4$, of large permeability, the authors made a series of mixed magnetic ferrites of type $NiFe_2O_4.CuFe_2O_4.ZnFe_2O_4$. The magnetic properties, permeability and loss, were studied as a function of the ratio copper ferrite/nickel ferrite and it is shown that if this ratio is >1 the properties resemble those of the initial copper ferrite whereas for values <1 the properties are near those of the pure nickel ferrite. Copper ferrites and copper-rich mixed ferrites show a considerable variation of magnetic properties with porosity. F.E.Hoare

6362 ANISOTROPY OF YIG CALCULATED FROM CRYSTAL FIELD PARAMETERS Fe^{3+} IN YTTRIUM GALLIUM GARNET.

S.Geschwind.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 263S (March, 1961).

An expression is given for the anisotropy of YIG in terms of the ground-state crystal field splitting parameters of Fe^{3+} in YGaG. The low-temperature anisotropy of YIG calculated from these crystal field parameters is 50% higher than the experimentally measured value. Several sources for this discrepancy are discussed.

6363 MAGNETIC ANISOTROPY OF YTTRIUM IRON GARNET AT 0° K.

L.R.Walker.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 264S-265S (March, 1961).

It is suggested that the discrepancy between the observed r.f. cubic anisotropy constant K_1 of yttrium iron garnet at 0° K and that predicted from the measurement of the crystal fields at octahedral and tetrahedral sites is to be ascribed to the zero point motion of the ferrimagnetic ground state.

6364 TORQUE MEASUREMENTS ON RARE-EARTH DOPED YTTRIUM IRON GARNET.

R.F.Pearson and R.W.Cooper.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 265S-267S (March, 1961).

This paper describes torque measurements made at 4.2 and 1.5° K on yttrium iron garnet crystals containing small rare-earth ion dopings. Resonance measurements by Dillon (1959), showed that the giant anisotropy peaks observed in yttrium iron garnet at 4.2° K were due to the presence of rare-earth ion impurities and since th his results on samples containing known impurities have been interpreted by Kittel (1960) in terms of energy-level "crossovers" of th rare-earth ion in the combined crystal field and exchange field. In the present work torque measurements have been made on several crystals with different rare-earth ion impurities, but results here are confined to crystals doped with terbium (Tb 0.19%), holmium (Ho 0.19%), and dysprosium (Dy 1.0%). The crystal containing dysp sium was grown by Page in the authors' laboratories. The torque curves were measured in a (110) plane, and in a (100) plane for the Tb sample, in a magnetic field of 15 000 Oe and the maximum torqu were in the range 20-200 dyne cm. For the three crystals, the energy surface deduced from the torque curves is consistent with t resonance field behaviour observed by Dillon (1959). The torque curve of the Tb crystal had more pronounced discontinuities than any other samples, and variation in the applied field between 5000 and 15 000 Oe altered the magnitude but did not alter the angle at which a particular discontinuity occurred. So far, attempts to correlate the position of the discontinuities in the (110) and (100) planes which showed fewer discontinuities have proved unsuccessfu with the above model. At 20° K the torque curve can be analysed i the standard way giving values of K_1 and K_2 of +88 000 and −460 000 erg cm^{-3} respectively. The torque curve for the Ho samp at 4.2° K was steepest at the [110] and [100] directions, in agreeme with the position of the resonance peaks reported by Dillon (1959). However, for the Dy crystal, no sharp discontinuities are observed and the torque curve shows a large sin 8θ component. On reducing the temperature from 4.2° to 1.5° K, no change in the curve was observed. The curves for Ho and Dy were found to be quite reversib in fields of 15 000 Oe.

6365 LOW-TEMPERATURE MAGNETIC PROPERTIES OF SOME RARE-EARTH GARNET COMPOUNDS.

M.Ball, G.Garton, M.J.M.Leask, D.Ryan and W.P.Wolf.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 267S-269S (March, 1961).

Low-temperature magnetic susceptibility measurements were carried out on single crystals of $Dy_3Al_5O_{12}$, $Dy_3Ga_5O_{12}$, $Er_3Al_5O_{12}$, $Er_3Ga_5O_{12}$, and diamagnetic $Y_3Al_5O_{12}$ and $Y_3Ga_5O_{12}$ containing nominally 1% Dy and Er. The dilute samples have also been investigat by paramagnetic resonance (9 kMc/s at 4.2° K), and with the excep of Dy in $Y_3Al_5O_{12}$ for which no resonance was found, the g tensors of the ground state doublets were determined in each case. A wid range of principal g values was found (1 to 11) and considerable differences between corresponding Al and Ga compounds were observed. These results show that the electronic ground states of th Dy^{3+} and Er^{3+} ions are in general very anisotropic in these structures, and that their magnetic properties are very sensitive to sm changes of environment. The susceptibility measurements also in cated the presence of low-lying crystal field states, and a weak, bu rather complex, interaction between the rare-earth ions. In the ca of $Dy_3Al_5O_{12}$ the interactions lead to antiferromagnetic ordering at 2.5° K Difficulties in applying these results to the interpretation o the properties of ferrimagnetic garnets containing Dy and Er are discussed.

6366 UNIAXIAL ANISOTROPY IN POLYCRYSTALLINE GARNETS.

D.J.Epstein, B.Frackiewicz and R.P.Hunt.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 270S-271S (March, 1961).

In samples of polycrystalline yttrium and lutetium iron garne which exhibit domain-wall relaxation effects, it is possible to estab lish uniaxial anisotropy by cooling to low temperature in a magneti field. This magnetic anneal leads to the development of rectangula hysteresis loops. In lutetium iron garnet, where a particularly strong anneal is found, a uniaxial anisotropy energy of 4500 erg/c is obtained. After cooling, the easy axis can be shifted in directio by altering the orientation of the applied field; the shift in axis occ with a finite time constant (order of 15 sec for LuFe garnet).

6367 DOMAIN WALL MOBILITY IN SINGLE-CRYSTAL YTTRIUM IRON GARNET.

F.B.Hagedorn and E.M.Gyorgy.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 282S-283S (March, 1961).

Reasonable agreement between the damping constant inferred from the resonance linewidth and that obtained from the domain wa mobility has previously been found for ferrites. However, the rece linewidths reported for yttrium iron garnet (YIG) by Spencer, LeCraw, and Clogston are substantially narrower than those for ferrites. Using this narrow linewidth to calculate the YIG wall

obility gives ~10^6 cm sec^{-1} Oe^{-1}. The YIG wall mobility was
easured as a function of temperature and found to be less than
cm sec^{-1} Oe^{-1}. This discrepancy can be interpreted in terms of
model for domain wall motion which is based on a type of energy
nversion process different from that usually assumed. The
stomary treatment requires that the domain wall dissipate
tirely to the lattice all of the magnetostatic energy stored in a
ven region during the time that the wall passes through this region.
r small damping such as exists in YIG, this requirement appears
be unreasonable. The wall motion model proposed here allows the
ll to be followed by a wake in which the original magnetostatic
ergy is temporarily stored as exchange, anisotropy, and demagneti-
ng energy. The measured wall velocities in single-crystal YIG
e in reasonable agreement with quantitative estimates based on
s model.

6368 DETERMINATION OF THE DIRECTIONS OF MAGNETIZATION IN POLYCRYSTALLINE FERRITES.

R.Callaby.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 298S-299S (March,
61).

To explain the switching properties of "square-loop" ferrites,
sumptions have had to be made as to the detailed configuration
the magnetization because of the lack of experimental evidence.
is paper presents a method, using the Kerr transverse magneto-
tic effect, to determine directly the direction of magnetization
individual grains across the surface of a ferrite toroid subject to
alternating magnetic field. A rectangular area of the ferrite
rface of size 200 × 160 μ is illuminated by a tungsten filament
urce, and the intensity of the reflected beam measured with a
rmanium photodiode. When the magnetization in the ferrite is
versed with an alternating field of 1100 c/s, a modulation of the
me frequency appears in the output of the photodiode. The depth
this modulation is approximately 0.01% of the d.c. output and
anges markedly as the light probe is traversed across the ferrite,
cause of the different directions of the magnetization in the
parate grains. By choosing a sample with grains of the same size
the light probe, it is possible to examine the light reflected from
individual grain. By rotating the grain around the light probe and
cording the variation in size of the modulation with angle, the
sposition of the magnetization in the grain as it reverses with the
plied field can be determined. Results obtained with a typical
uare-loop ferrite composition are presented and discussed.

6369 PREPARATION AND PROPERTIES OF LOW-LOSS FERRITES. A.P.Greifer, Y.Nakada and H.Lessoff.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 382S-383S (March,
61).

NiZn ferrites containing 1-3 mole Co ferrite and small addi-
ns of molybdenum oxide or vanadium oxide were prepared with
Q products ranging from 50 000 at 1.0 Mc/s 4500 at 60 Mc/s. The
fect of stoichiometry, ferrous iron content, firing temperature,
d firing time on the initial permeability μ_0 and the magnetic
ality factor Q is discussed. It is believed that a necessary condi-
n for good high-frequency response is the domination of the
sonance phenomena by a spin-rotation mechanism in preference
a domain-wall process. The Ni ferrite—Zn ferrite system appears
be unique in this respect. In properly constitued NiZn ferrites,
v-loss characteristics are achieved by combining a relatively high
nsity with a low magnetocrystalline anisotropy and a very small
ain size. The properties in general are intimately related to the
rminvar characteristics these compositions possess, and are
erpreted in terms of the Néel—Taniguchi theory.

6370 EFFECT OF COBALT OXIDE IN POROUS NICKEL FERRITES AT VERY HIGH FREQUENCY. H.F.Remde.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 384S-385S
arch, 1961).

Very high frequency measurements of a series of porous, low-
s ferrites ($NiO_{(1-x)}CoO_xFe_2O_3$) are described. In many cases, a
sonance-type dispersion appears. Comparison of the data with
ory indicates that the dispersion results not from domain rotation
from high-frequency wall resonance. Extrapolation of the data
x = 0 to theoretical density gives results which are consistent
h single-crystal measurements suggesting that the loss in porous
kel ferrite occurs in small, relatively perfect regions or grains.

6371 INITIAL PERMEABILITY CHARACTERISTICS OF VANADIUM-DOPED MANGANESE—ZINC FERRITES.

hichijo, N.Tsuya and K.Suzuki.
appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 386S-387S
arch, 1961).

The basic composition of MnZn ferrites used in this experiment is represented by $(MnO)_{27}(ZnO)_{20}(Fe_2O_3)_{53}$. When doped by a small amount of vanadium and calcium, a significant reduction of high-frequency losses was observed. Measured toroidal specimens were prepared by standard sintering techniques, and special precautions have been taken to maintain the sintering temperatures within ±2 degrees. Initial permeability μ, $\mu^{-1}\tan\delta$, and the hysteresis coefficient h_{10} were measured by a Maxwell bridge at room temperature. In these experiments it was found that, under certain sintering conditions, losses are minimized by the use of adequate amounts of vanadium doping yielding less than 3×10^{-6} and 20 of $\mu^{-1}\tan\delta$ and the hysteresis coefficient h_{10}, respectively. The loss analysis, granular structure observation and electrical resistivity measurements were also performed.

6372 EFFECT OF INDIUM SUBSTITUTION IN YTTRIUM IRON GARNET. HIGH PERMEABILITY GARNETS.

J.R.Cunningham, Jr and E.E.Anderson.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 388S-389S
(March, 1961).

Initial studies on the effect of small substitutions of indium for iron in polycrystalline yttrium iron garnet showed a substantial increase in the initial permeability over that of YIG. Since previous substitution of other ions has produced either little change or a decrease in the permeability, a study was made of the effect of indium substitution on the garnet structure in more detail. Due to the size increase of In^{3+} radii over that of Fe^{3+}, the substitution on In^{3+} into the garnet structure is limited to the larger of the available Fe^{3+} sites. The general formula can be written $Y_3(Fe_{2-x}In\ )Fe_3O_{12}$ where x may take on values up to 2.0 X-ray determination of the lattice parameters for this series shows a linear dependence on x with an apparent change in slope for $x > 0.6$. For $x < 0.65$ there is no "detectable" trace of a second phase and the lattice constants vary from 12.376 ± 0.005 A ($x = 0$) to 12.445 ± 0.005 A ($x = 0.6$). For $x = 0.65$ a small perovskite phase is present, which becomes more apparent with larger x. Since the lattice constant of the garnet phase in the two-phased samples does increase with x, it appears that x will enter the garnet structure for $x > 0.65$. However, repeated firings at various temperatures failed to remove the perovskite phase. The relative initial complex permeability μ^* was measured over a frequency range from 10^3 to 2×10^9 c/s on high density toroids. Increases in μ_0', the low-frequency value of μ', over that of YIG were found for all of the single-phased garnets in the series. A plot of μ_0' as a function of x shows an essentially linear increase from $\mu_0' = 112$ for $x = 0$ (YIG) to $\mu_0' = 518$ for $x = 0.6$. Measurements of μ_0' as a function of temperature up to the Curie point for this series are also presented. Magnetic moment measurements were made from -196° C to the Curie temperature for this series. As in the case of other substitutions for Fe^{3+}, the substitution of In^{3+} resulted in a decided decrease in the Curie temperature from $278 \pm 2^\circ$ C for YIG to $Tc = 148 \pm 2^\circ$ C for $x = 0.6$. The room temperature moment is only slightly higher than that of YIG ($6.8\mu_B$). On the basis of comparison of their thermal magnetic properties, it could be expected that Sc^{3+} substitution in small amounts would also produce a rise in μ_0'. The increase in μ_0' is attributed to the lowering of the Curie temperature while the magnetic moment is held nearly constant or slightly increased.

6373 FERRITE SYSTEM FOR APPLICATION AT LOWER MICROWAVE FREQUENCIES.

C.F.Jefferson and R.G.West.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 390S-391S
(March, 1961).

The ferrimagnetic system $(LiFe)_{1-0.5a-0.5x}Zn_xFe_{2a-y}Ti_{1-a}Al_yO_4$ is found to form a single-phase solid solution for the investigated values $0 \leq a \leq 1$, $0 \leq x \leq 0.1$, and $0 \leq y \leq 0.15$. For approximately $0.2 \leq a \leq 0.4$, the system exhibits relatively high Curie temperatures and properites compatible with the requirements of ferrites for utilization in nonresonant devices at the lower microwave frequencies.

6374 EXCHANGE INVERSION IN $Mn_{2-x}Cr_xSb$.

W.H.Cloud, T.A.Bither and T.J.Swoboda.
J.appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 55S-56S (March, 1961).

Compounds of the form $Mn_{2-x}Cr_xSb$ show a first-order ferrimagnetic to antiferromagnetic phase transition with decreasing temperature. Sublattices composed of the three adjacent ferrimagnetically aligned (001) planes Mn(II)-Mn(I)-Mn(II) are ferromagnetically ordered above the transition temperature T_S and antiferromagnetically ordered below T_S. The exchange interaction between these sublattices changes sign at a critical interlayer distance. The discontinuous change in interlayer distance at T_S is proportional to the square of the magnetization of the sublattice in agreement with Kittel's conclusions.

6375 MAGNETIC ANISOTROPY AND ELECTRICAL RESISTIVITY IN EXCHANGE INVERSION COMPOUNDS.

H.S.Jarrett, P.E.Bierstedt, F.J.Darnell and M.Sparks.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 57S-58S (March, 1961).

Magnetic anisotropy and electrical resistivity were determined for several materials of composition $Mn_{2-x}Cr_xSb$, which exhibit a ferrimagnetic to antiferromagnetic phase transformation with decreasing temperature. Magnetocrystalline anisotropy is similar in its temperature behaviour to that of Mn_2Sb with slight differences attributed to changes in magnetic moment of the Mn sublattices. Resistivity is attributed to electron—magnon scattering. The magnetocrystalline anisotropy at the two Mn sites of nearly equal magnitude but opposite sign is consistent with the small anisotropy of the magnetoresistance.

6376 MAGNETIC PHASES OF THE PEROVSKITE TYPE.

R.Ward and J.Longo.

J. Amer. Chem. Soc., Vol. 82, No. 22, 5958-9 (Nov. 20, 1960).

A series of compounds, of the type $A_2^{II}(B^{II}Re^{VI})O_6$, containing the paramagnetic ion hexavalent rhenium have been prepared. One group had the composition $Ba_2(MRe)O_6$ where M = Mn, Fe or Co. Sr replaced Ba in another group. The substances appear to be ferrimagnetic when they contain Mn or Fe. Approximate Curie temperatures are: $Ba_2(FeRe)O_6$, 40°C; $Ba_2(MnRe)O_6$, −137°C; $Sr_2(FeRe)O_6$, 128°C. The Co compound gave no magnetic response over the temperature range used; it is probably antiferrimagnetic.

J.Iball

6377 PERTURBATION THEORY OF ANTIFERROMAGNETISM.

R.L.Mills, R.P.Kenan and J.Korringa.

Suppl. to Physica (Netherlands), Vol. 26, S204-S214 (Dec., 1960).

International Conference on Many-Particle Problems, Utrecht, 1960 (see Abstr. 1707 of 1961). A connected diagram expansion for thermodynamic properties of an antiferromagnetic spin system is derived. The theory can be modified by including a real effective field in the unperturbed Hamiltonian at low temperatures, or an imaginary effective field at high temperatures. Problems involved in making a partial summation of diagrams are discussed.

D.J.Thouless

6378 A LATTICE MODEL OF A CLASSICAL HARD SPHERE GAS. II.

D.M.Burley.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 451-8 (Feb., 1961).

For Pt I see Abstr. 6831 of 1960. It was shown in Pt I that the anitferromagnetic Ising model could be transformed into a model of a hard-sphere lattice gas. For the model of the loose-packed lattices, a transition from an ordered to a disordered phase was suggested. No firm results could be obtained, however, since the approximation used for the ordered phase was inadequate. It is now shown that the pressure and free energy curves of both phases can be calculated on the Bethe and "ring" approximation. In each case a transition is shown to occur and to be of the second order.

6379 ANTIFERROMAGNETISM OF α-Mn AND ITS ALLOYS.

A.Arrott and B.R.Coles.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 51S-52S (March, 1961).

Low-temperature magnetic isotherms of α-Mn and its alloys with Fe, N, and H have been examined. Hysteresis loops and effects of cooling in an applied field are reported. Similar properties are found for single crystals of Cu--Mn. It is pointed out that the spin density wave mechanism of antiferromagnetism, proposed by Overhauser, provides explanations for these phenomena. Neutron diffraction data are reinterpreted and provide further evidence for spin density waves in α-Mn and its alloys.

6380 SPIN-FLOPPING IN MnF_2 BY HIGH MAGNETIC FIELDS.

I.S.Jacobs.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 61S-62S (March, 1961).

Observations of spin-flopping, or decoupling between the direction of antiferromagnetism and the easy axis of the crystal, are presented for $MnFe_2$ in single crystal and powder form at low temperatures. Magnetization measurements in pulsed fields to 140 kOe are employed to explore the critical interaction energy in this antiferromagnet, as an alternative tool to microwave resonance. The orientation dependence predicted by Néel in 1936 is confirmed. The critical field for spin-flopping given by the combination of anisotropy and exchange $(2H_EH_A)^{\frac{1}{2}}$, is found to be 93 ± 2 kOe in excellent agreement with resonance results of Foner (Abstr. 2404 of 1958; 13863 of 1960), and Johnson (Abstr. 2419 of 1957; 9801 of 1959).

6381 ANTIFERROMAGNETIC MATERIALS FOR MILLIMETER AND SUBMILLIMETER DEVICES.

G.S.Heller, J.J.Stickler and J.B.Thaxter.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 307S-312S (March, 1961).

Owing to their high internal fields, antiferromagnetic materials have natural resonant frequencies in the millimetre and submillimetre wavelength region of the electromagnetic spectrum. Since these normal modes are circularly polarized and can be tuned by an applied magnetic field, devices similar to the usual ferrite devices are possible at these high frequencies with the application of relatively low fields. The dynamics of a simple antiferromagnetic system are briefly reviewed and the important quantities which characterize antiferromagnetic devices are discussed. The figures of merit for antiferromagnetic resonance isolators and phase shift devices are discussed. Experimental data on resonant frequency and linewidth, as well as a typical nonreciprocal resonance absorption trace showing a reverse to forward loss of 10 to 1 in chromic oxide at 140 Gc/s and at 77°K are presented.

6382 MAGNETIC MOMENTS OF COMPOUNDS OF COBALT WITH RARE-EARTH ELEMENTS HAVING A Cu_5Ca STRUCTURE.

E.A.Nesbitt, H.J.Williams, J.H.Wernick and R.C.Sherwood.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 342S-343S (March, 1961).

Recently, the compound Co_5Gd was shown to have antiferromagnetic coupling. The present work is on compounds of this type in which most of the rare-earth elements have been substituted for Gd and Cu has been substituted for some of the Co. The rare-earth elements which have a high magnetic moment (Gd, Tb, Dy, Ho, Er, Tm) have an effect on the magnetization versus temperature curve which is startling. The moment is greatly reduced in the vicinity of 0°K in the presence of one of these elements, in contrast to the high moment obtained when Y or a low-moment rare-earth element (Ce, Pr, Nd, Sm) is present. As a result of these measurements, the magnetic structure of most of the compounds of cobalt with a rare-earth element may be considered as consisting of a sublattice of the rare-earth whose magnetic moment is in opposition to that of the sublattice of the cobalt atoms. All of the compounds conform to this picture with reasonable accuracy except those which contain Pr and Nd. In these two cases, the moment of the compounds is actually increased but the reason for this behaviour was not determined. The presence of compensation points in the magnetization of some of these materials was demonstrated experimentally.

6383 ANTIFERROMAGNETIC BEHAVIOUR OF GdB_6.

B.R.Coles and D.Griffiths.

Proc. Phys. Soc. (GB), Vol. 77, Pt I, 213-15 (Jan., 1961).

The susceptibility of very pure GdB_6 was measured in a temperature range up to 300°K. A sharp maximum is observed at 13°K and this is attributed to antiferromagnetic ordering. The reciprocal susceptibility increases linearly with temperature above 100°K and yields a moment of 7.78 ± 0.05 μ_B per gadolinium atom and an asymptotic temperature of -60°K. The theoretical value for Gd^{+++} is 7.94 μ_B. The separation of Gd atoms is 4.1 A, so that direct interactions must be weak. Superexchange interaction via boron ions may play a part in the antiferromagnetic interaction but an interaction via the conduction electrons is considered to be more likely.

R.Parker

6384 PARALLEL SUSCEPTIBILITY OF AN ANTIFERROMAGNETIC CRYSTAL, WITH TWO MAGNETIC SUBLATTICES, AT LOW TEMPERATURES.

A.Corciovei.

Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 4, 399-413 (1957). In Roumanian.

A new method is presented for calculating the parallel susceptibility, at low temperatures, of an antiferromagnetic crystal with two sublattices. The spin wave formalism of Holstein—Primakoff is used and the method of procedure is based on a consideration of the Zeeman term in the Hamiltonian as a perturbation in relation to the remainder. The degeneration of the non-perturbed levels is removed and the sum over states evaluated in an exterior magnetic field. The results obtained are in accordance with those given by other authors.

F.E.Hoare

6385 MAGNETIC SUSCEPTIBILITY OF $FeCl_2.4H_2O$ AT LOW TEMPERATURES.

R.D.Pierce and S.A.Friedberg.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 66S-67S (March, 1961).

The magnetic susceptibility of powdered $FeCl_2.4H_2O$ was measured between 1.3° and 4.2°K and from 14° to 21°K by an a.c. mutual inductance method. A maximum, apparently associated with antiferromagnetic-paramagnetic transition, is found near 1.6°K. the hydrogen region, a Curie—Weiss law is obeyed, the Curie nstant yielding a splitting factor $g = 2.19$ for the Fe^{++} ion if its fective spin is assumed to be $S = 2$.

6386 REMARKS ON THE MAGNETIC PROPERTIES OF Au—Mn SYSTEM.

H.Sato.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 53S-54S (March, 1961).

The nature of the interaction between Mn atoms which is sponsible for the helical magnetic structure and the metamagnetic haviour of Au_2Mn is examined by analysing the magnetic behaviour the Au—Mn system in general. From a comparison of the magnetic ructure of Au_2Mn and that of Au_4Mn, the magnetic dipole intertion is suggested as one of the possible main weak interactions hich connects the successive layers of Mn atoms of Au_2Mn.

agnetic Resonances

6387 ANISOTROPY OF THE SPIN-WAVE SPECTRUM.

M.W.Muller and C.R.Buffler.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 152S-154S (March, 61).

The frequency of a spin-wave depends on its propagation vector d on the effective internal field in which it propagates. In an isoopic medium this implies that all the spin-waves of a given wavength lying on a θ_k cone about the effective field are degenerate. anistropic media this degeneracy is removed in those directions which the minimum of the energy surface is not axially symmetric. is effect can be observed by measuring the contribution to the rromagnetic resonance linewidth from scattering into moderate-k in-waves as a function of frequency and orientation in single ystal samples. Theoretical predictions and experimental results e given for a sphere of yttrium iron garnet.

6388 FERROMAGNETIC RESONANCE ABSORPTION IN FERRITES.

Y.Torizuka, Y.Kojima and T.Okamura.

ysica (Netherlands), Vol. 26, No. 3, 175-8 (March, 1960).

Ferromagnetic resonance experiments were carried out at equencies of 9370, 19230 and 28850 Mc/s to determine the g-factor r Ni-Zn binary ferrite which was calculated from the corrected ttel resonance formula, including the internal field in the material: e origin of the internal field was also studied. The dependence of e g-factor on the composition of Ni-Zn binary ferrite is explained tisfactorily by the theory of Tuya and Wangsness.

6389 NOTE ON THE GYROMAGNETIC RATIO OF Co^{++} AND ON THE JAHN—TELLER EFFECT IN Fe^{++}.

.H.van Vleck.

hysica (Netherlands), Vol. 2, No. 7, 544-52 (July, 1960).

By the method of pseudo-angular momentum is meant the tilization of the fact that in a triply degenerate level in a cubic eld, the orbital angular momentum obeys the same commutation ules as for a p state, except for a proportionality factor. This ethod is used to calculate the gyromagnetic ratio of a Co^{++} ion a cubic field. The value thus obtained is 1.65, in better agreeent with Sucksmith's experimental measurements on $CoSO_4$ and oCl_2 than is the spin-only value $g = 2$, even though these materials o not have cubic symmetry. The other application is to the Jahn—eller effect in Fe^{++}. An explanation is given why Low finds no vidence of this effect in his magnetic resonance measurements on e^{++}, and at the same time this mechanism plays an important role the Abragam—Pryce theory of the magnetic susceptibility of opper fluosilicate. At first sight, one would except the Fe^{++} ion show a large Jahn—Teller effect, as its lowest level is triply egenerate even when spin—orbit interaction is included; however, e linear terms in the distortional coordinates have very small oefficients and so are ineffective.

6390 THE EFFECT OF LONG-RANGE MAGNETIC ORDER FLUCTUATIONS ON THE TEMPERATURE EPENDENCE OF LINE-WIDTHS IN FERROMAGNETIC ESONANCE ABSORPTION.

G.V.Skrotskii and L.V.Kurbatov.

z. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 335-40 ept., 1960). In Russian.

Gives a simple statistical-thermodynamic theory of fluctuation oadening of ferromagnetic resonance absorption line-widths near e Curie point. A.Tybulewicz

6391 THE S—D EXCHANGE INTERACTION AND RESONANCE IN FERROMAGNETIC METALS.

Yu.A.Izyumov and Yu.Ya.Polyak.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 641-9 (Nov., 1960). In Russian.

Reports a calculation of the complex magnetic susceptibility of a ferromagnetic transition metal as a function of the frequency of an applied magnetic field. Shows that in samples with dimensions smaller than the depth of penetration of the skin effect, quanta of a uniform alternating field are absorbed with generation of spin waves of zero quasi-momentum. The exchange interaction between conduction electrons and electrons in partially filled shells with uncompensated spin does not shift the resonance frequency nor does it broaden the absorption line. A.Tybulewicz

6392 ON THE THEORY OF FERROMAGNETIC RESONANCE II.

S.V.Tyablikov.

Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2009-18 (Sept., 1960). In Russian.

For abstract, see Abstr. 2489 of 1961. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 1805-13 (March, 1961)].

6393 REPORT ON FERROMAGNETIC RESONANCE AT THE 1960 CONFERENCE ON MAGNETISM AND MAGNETIC MATERIALS.

G.T.Rado.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 129S-139S (March, 1961).

An integrated summary is given of some of the results and physical ideas contained in 16 experimental and theoretical papers on ferromagnetic resonance contributed to the 1960 Conference on Magnetism and Magnetic Materials. The topics discussed include the uniform mode and anisotropy, nonuniform magnetostatic and electromagnetic modes, spin-wave resonance, sublattice effects, paramagnetic "impurities", spin-wave scattering, rapidly relaxing ions, determination of spin-wave transition probabilities, thermal relaxation, and the theory and use of the "parallel pump" method for measuring relaxation and exchange parameters. Although a complete review of ferromagnetic resonance is not intended, the emphasis is on an organization of this field and on the introductory and explanatory material presented with each topic.

6394 MICROWAVE RESONANCE IN TETRAGONALLY DISTORTED MANGANESE—IRON SPINEL.

J.Overmeyer.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 142S-143S (March, 1961).

A single crystal of tetragonally distorted manganese—iron spinel of composition $Mn_{1.85}Fe_{1.15}O_4$ was studied by microwave resonance in the temperature range 77-390°K. The anisotropy has tetragonal symmetry, with the c axis hard and the tetragonal a axis (corresponding to the [110] direction in the undistorted cubic structure) easy. The data are analysed in terms of an anisotropy energy of the form:

$$E_A = K_1\alpha_3^{\,2} + K_2\alpha_3^{\,4} + K_3(\alpha_1^{\,4} + \alpha_2^{\,4}),$$

wherein α_1 and α_2 are direction cosines of the magnetization referred to the tetragonal a axes, and α_3 is the direction cosine of the magnetization referred to the c axis. The second-order axial component K_1/M is approximately 3 kG at room temperature and remains relatively constant as the temperature is lowered to 160°K, below which it increases rapidly. The quantity K_3/M, which measures the anisotropy in the basal plane, is about -25 G at room temperature and increases to a few hundred gauss at 77°K. A temperature independent $g_{eff} = 2.01$ adequately describes the measurements. Linewidths vary from 250 G in the tetragonal [110] direction to 400 G in the c direction at room temperature and increase with decreasing temperature.

6395 FERROMAGNETIC RESONANCE IN PIEZOELECTRIC $Ga_{2-x}Fe_xO_3$.

A Dymanus and I.P.Kaminow

J. appl Phys. (USA), Suppl. to Vol. 32, No. 3. 144S-145S (March, 1961).

Microwave resonance measurements at 55 kMc/s and lower frequencies on $Ga_{2-x}Fe_xO_3$ single crystals which are both ferromagnetic and piezoelectric were made from room temperature to the Curie point. The crystals exhibit a large orthorhombic anisotropy with easy, intermediate, and hard directions along the orthorhombic c, a, and b axes respectively ($c < a < b$). Linewidths are approximately 1 kOe and anisotropy fields approximately 17 kOe at room temperature. The origin and representation of the anisotropy is discussed.

6396 FERROMAGNETIC RESONANCE DUE TO MAGNETIC FIELDS GENERATED BY DISPLACEMENT CURRENTS IN FERRITES.

I.Bady and G.McCall.
J. appl. Phys. (USA), Suppl. To Vol. 32, No. 3, 146S-147S (March, 1961).

The displacement current due to the interaction of the relatively high dielectric constant of a ferrite with the electric field in a waveguide generates a magnetic field which may be comparable to the transverse magnetic field in the unperturbed waveguide. Hence, a thin ferrite rod located at an E field maximum (H field minimum) may experience a strong ferromagnetic resonance absorption even though the r.f. magnetic field at the rod, due to the unperturbed waveguide modes, is negligible. A formula is given for the ratio of energy absorbed when the rod is at an E field max as against being at an H field max. A formula is also given for the biasing field required for resonance when the rod is at an E field max. Test results agree well with theory.

6397 EXCITATION AND BOUNDARY EFFECTS IN SPIN-WAVE RESONANCE.

R.F.Soohoo.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 148S-150S (March, 1961).

Using the general spin-wave dispersion relation and the general exchange boundary condition, the spin-wave absorption spectrum in a Permalloy film is calculated. Whereas the spacings between the various spin-wave resonance peaks are largely dependent upon the value of the exchange constant A, the result of the calculation shows that the relative intensities of the absorption peaks are dependent upon both A and the surface anisotropy energy density K_S. Thus, the value of K_S can be obtained by comparing the relative experimental intensities of the various peaks with the calculated results using various values of assumed K_S. Though the resonance intensities are also dependent upon the ratio of the r.f. magnetic fields at the two surfaces of the film, an experimental configuration may be devised such that the ratio of the two fields is near unity. In this way, $|K_S|$ for Permalloy films was estimated to be from 1 to 3 erg/cm^2.

6398 FERROMAGNETIC RESONANCE LINEWIDTH IN COBALT-SUBSTITUTED FERRITES.

C.W.Haas and H.B.Callen.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 157S-158S (March, 1961).

The resonance linewidth contribution of small concentrations of cobalt ions substituted in ferrites is investigated by computing the magnon scattering due to the variation from ion to ion of the spin-orbit interaction. The effect of the spin-orbit coupling is particularly large in the cobalt ion because it has a degenerate orbital ground state when situated in a trigonally symmetric crystalline field. The resultant linewidth is found to be of the order of 20-30 Oe for each percent of cobalt introduced into a normal (noninversed) ferrite or into magnetite. For other ferrites, the effect of the cobalt ions is diminished because the nonequivalence of all octahedral-site ions destroys the trigonal symmetry of the local crystalline field and lifts the orbital groundstate degeneracy. This diminution is calculated as a function of the degree of inversion.

6399 HIGH-POWER CHARACTERISTICS OF LOW-MAGNETIZATION GARNETS.

J.H.Saunders and J.J.Green.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 161S-162S (March, 1961).

Large signal ferromagnetic resonance measurements were performed on low-magnetization polycrystalline garnets in which aluminium or gallium had been partially substituted for iron. Measurements were made at 1.3, 5.5, and 9.3 kMc/s. For some samples the temperature was varied between 77° K and the Curie temperature. The results are in qualitative agreement with recent theories of ferromagnetic relaxation.

6400 RESONANT FREQUENCY SHIFT IN ELLIPSOIDAL SAMPLES.

T.Matcovich, H.S.Belson and N.Goldberg.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 163S-164S (March, 1961).

A polished, ellipsoidal, single crystal, yttrium iron garnet sample with rotation axis along a [100] direction and $\Delta H = 1.0$ Oe was prepared. X-band measurements of the microwave resonant frequency were made as a function of r.f. power. The resonant frequency was found to shift at the rate of 41 Mc/s per watt. The shift of the resonant frequency was related to the number of $k = 0$ magnons (n_0) and the number of $k \neq 0$ magnons (n_k) by means of spin-wave theory. From this relation and the experimental data the value of n_k/n_0 was determined to be 2.7.

6401 INSTABILITY OF MAGNETOSTATIC MODES IN A MICROWAVE MAGNETIC FIELD APPLIED PARALLEL TO THE D.C. FIELD.

E.Schlömann and R.I.Joseph.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 165S-167S (March, 1961).

Previous calculations of the instability threshold have been based on a plane-wave analysis which is strictly applicable only in an infinite medium. This paper describes a more rigorous theory in which the boundary conditions at the surface of the sample are taken into account. The refined theory admits instabilities at frequencies different from half the pump frequency, which are forbidden according to the less rigorous plane-wave analysis. The general theory is applied to the magnetostatic modes of a long, circular cylinder, which is magnetized along its axis. It is concluded that: (1) Pairs of surface modes (with frequencies higher than the highest plane-wave frequency) are not subject to instability. (2) Instability at half the pump frequency can occur only for those cases in which the magnetostatic potential is invariant under rotation around the cylinder axis ($m = 0$). The instability threshold for these modes is identical to that deduced on the basis of the plane-wave analysis except that the frequencies now have to satisfy the characteristic equation derived from the boundary conditions. (3) Instabilities at frequencies different from half the pump frequency can occur, but generally have a higher threshold.

6402 FERROMAGNETIC RELAXATION AT LOW MICROWAVE FREQUENCIES.

J.J.Green and E.Schlömann.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 168S-170S (March, 1961).

The theory of three-magnon relaxation processes is summarized, and it is shown that such processes are very likely to be important at low microwave frequencies. The instability threshold in an r.f. magnetic field applied parallel to the d.c. field has been measured in yttrium iron garnet at room temperature as a function of the d.c. field at five frequencies between S and X band. The results of these measurements are in qualitative agreement with the theoretical predictions.

FERROMAGNETIC RESONANCE OF MAGNETITE. See Abstr. 6281

6403 FERRIMAGNETIC RESONANCE IN SINGLE CRYSTALS OF COBALT-SUBSTITUTED MANGANESE FERRITE.

R.W.Teale and M.J.Hight.
J. appl Phys. (USA), Suppl. to Vol. 32, No. 3, 140S-141S (March, 1961).

The results of microwave resonance measurements of the g factor and the first- and second-order anisotropy fields K_1/M and K_2/M are summarized for crystals with the nominal composition $Co_xMn_{1-x}Fe_2O_4$, where $0 \leq x \leq 0.10$. In the region $150^\circ K < T < 300^\circ K$, $\Delta(K_1/M) = Ax$, $\Delta(K_2/M) = -Bx$ and $g = a + bx$. $\Delta(K_1/M)$ is the cobalt contribution to K_1/M; similarly for $\Delta(K_2/M)$. The results for K_1/M are in agreement with published values determined statically on the same crystals. For $T = 290^\circ, 260^\circ, 230^\circ, 200^\circ, 170^\circ$, and $140^\circ K$, B is 510, 1790, 4600, 10 300, 22 400, and 50 000, respectively. At 260° K the values for a and b are 2.003 and 0.41 respectively, at 9400 Mc/s; at 17 000 Mc/s the values are 1.992 and 0.42. For the lower frequency at 170° K the values are 2.004 and 0.64. The two microwave frequencies were used only above 77° K; in this range the g values are isotropic to better than 0.5%. At 4.2° K the effect of the cobalt upon the variation of resonance field with direction in a (110) plane cannot be accurately described by K_1/M and K_2/M. The results are compared with the successful theory for the cobalt ion substituted into Fe_3O_4. It appears that modification of the original model is necessary to take into account the differing environment of the cobalt ion when substituted into $MnFe_2O_4$.

6404 FERRIMAGNETIC RESONANCE AND TORQUE MEASUREMENTS ON YTTERBIUM-SUBSTITUTED YTTRIUM IRON GARNET.

R.W.Teale, R.F.Pearson and M.J.Hight.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 150S-151S (March, 1961).

It is pointed out that the comparison of microwave resonance and static torque measurements on single-crystal samples may enable relaxation effects in the former to be identified. Such a comparison is made for a crystal of nominal composition $(Yb_{0.021}Y_{0.979})_3Fe_5O_{12}$ in the temperature range 4.2-250° K. It is shown that for this crystal, as in $Yb_3Fe_5O_{12}$, the anisotropy in H_r, the field resonance, is not due only to magnetocrystalline energy in a range of temperatures below 220°K. It is suggested that the extra reduction in H_r observed, which occurs most strongly in the [111] directions, is associated with the heavily damped motion of the magnetization of the ytterbium ion. Both types of measurement show that between 20 and 4.2°K, the magnetocrystalline energy surface of the ytterbium ion changes very rapidly and develops sharp curvature.

6405 FERRIMAGNETIC RESONANCE IN A SINGLE-CRYSTAL DISK OF YTTRIUM IRON GARNET.

A.W.Smith and A.Watanabe.

J. appl. Phys. (USA), Suppl to Vol. 32, No. 3, 155S-156S (March, 1961).

The use of a disk instead of a sphere for the investigation of the uniform mode is discussed briefly. The discussion and the experiments are restricted to a disk with the d.c. field perpendicular to the plane, and to a single-crystal sample of YFe garnet. Resonance measurements were carried out on a disk 0.157 cm in diameter and 0.0085 cm in thickness. The linewidth and saturation curve were determined in a shorted coaxial line by detecting changes in v.s.w.r. with a slotted line and probe. The frequency was 1980 Mc/s. The linewidth was (0.78 ± 0.05) Oe, and the line shape appeared to be Lorentzian. The critical r.f. field for saturation was found to be $(5.2 \pm 0.3) \times 10^{-3}$ Oe by extrapolation of the $1/h_{rf}$ portion of the saturation curve. The resultant linewidth of the unstable z-directed spin wave 0.08 Oe. This is 20 times smaller than the value reported for a sphere at 6200 Mc/s.

6406 NEW CHARACTERISTIC IN THE TEMPERATURE DEPENDENCE OF FERRIMAGNETIC RESONANCE LINEWIDTH IN SOME RARE-EARTH DOPED YTTRIUM IRON GARNETS.

J.F.Dillon, Jr.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 159S-160S (March, 1961).

Measurements have been made of the ferrimagnetic resonance linewidth of YIG doped with each of the rare earths. These results will be presented in full elsewhere. For the most part there is a peak in the $\Delta H(T)$ curve at some temperature between 20° and 150°K. The position of this peak varies with the impurity, the frequency, and the crystal direction of the steady field. However, several cases have been observed in which the linewidth increases very rapidly with decreasing temperature down to the lowest temperature reached, about 1.5°K. This behaviour occurs over a very narrow angular range. For ytterbium-doped YIG, it is associated with a very mild peak in the field for resonance. For the case of europium there appears to be no anomaly in H_{res}, though a plot of linewidth against angle shows an increase of about fifteen-fold with a half-width of perhaps 1.5°. It is suggested that this anomalous linewidth versus angle and temperature curve, as well as the more generally encountered peak in $\Delta H(T)$, represent the excitation of transitions between sublevels of the rare-earth multiplet which approach within an energy comparable to that of a photon of the exciting radiation.

6407 SUBSIDIARY RESONANCE IN YIG.

T.S.Hartwick, E.R.Peressini and M.T.Weiss.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 223S-224S (March, 1961).

The real and imaginary components of susceptibility at subsidiary resonance have been measured for a polished YIG sphere at 9253 Mc/s. These measurements were made as a function of d.c. magnetic field and power level for h_{rf}, both parallel and perpendicular to the applied magnetic field, with a c.w. and a pulsed pumping source. The initial increase in χ'' with power level for a c.w. source is found to be much more gradual than theory would predict for the perpendicular case. Furthermore, intense relaxation oscillations are observed at high power levels for both parallel and perpendicular pumping. The real part of the susceptibility, χ', shows a small increase for the parallel pumped case; for the perpendicular pumped case χ' first decreases and then increases with respect to its low power value as H_{dc} traverses the subsidiary resonance.

6408 PARAMETRIC EFFECTS IN MAGNETOACOUSTIC RESONANCE.

R.L.Comstock, B.A.Auld and G.Wade.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 225S-226S (March, 1961).

Experimental and theoretical results are presented to substantiate the parametric origin of the excitation of megacycle frequency acoustic modes in a polished YIG sphere by microwave power. A method is described for measuring the acoustic Q using a component of transverse magnetization varying at the acoustic frequency to induce a voltage in a loop placed around the sphere. The response of the magnetostatic acoustic mode system for microwave powers less than that necessary to excite the acoustic oscillation has been investigated. An equivalent circuit of the system is derived which explains the observed results.

6409 NONLINEAR RESPONSE OF YIG.

R.M.Hill and R.S.Bergman.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 227S-228S (March, 1961).

A small signal study of the second harmonic produced by a small YIG single crystal shows that the anisotropy energy, K_1, is the dominant nonlinear term. This should be true for any ferrimagnet for which $|K_1/(M_S\Delta H)| > 1$. At signal levels above saturation a periodic amplitude modulation of the second harmonic level occurs, which may be due to an exchange of energy between longitudinally and transversely radiating modes.

TRAVELLING-WAVE FREQUENCY DOUBLING IN FERRITES. See Abstr. 5588

FINE-WIRE FERRITE LIMITER. See Abstr. 5587

6410 SPIN-WAVE RESONANCES IN ANTIFERROMAGNETICS.

H.Cofta.

Acta phys. Polon. (Poland), Vol. 19, No. 2, 187-91 (1960).

The purpose of this paper is to ascertain whether a spin-wave resonance effect in antiferromagnetics analogous to that predicted by Kittel (Abstr. 8876 of 1958) for ferromagnetics is possible. By means of semiclassical formalism, the author shows the possibility of exciting odd modes of spin waves in antiferromagnetics and calculates the resonance values of applied magnetic field for these modes. Each mode can be excited by two different values of applied field. The investigated phenomenon might be observable in films 3-10 times thicker than in the case of ferromagnetics.

6411 FERRIMAGNETIC SPIN-WAVE RESONANCE.

H.Cofta.

Acta phys. Polon. (Poland), Vol. 19, No. 2, 193-8 (1960).

Presents a theoretical investigation of the possibility of exciting spin-wave modes in ferrimagnetics by a uniform r.f. field. Ferrimagnetics with parallel spins, as well as those with antiparallel spins, are considered. The resonance values of applied magnetic field for allowed odd modes of spin waves and for a given value of the frequency of r.f. magnetic field are obtained. For even modes the resonances do not appear, provided that eddy currents can be neglected and that spin waves have nodes at the boundaries. In the special case of ferromagnetics one gets the formula of Kittel (Abstr. 8876 of 1958) and in the case of antiferromagnetics the resonance formula goes over into that derived by Cofta (see preceding abstract). The author estimates also the interval between successive odd mode peaks.

6412 ANTIFERROMAGNETIC RESONANCE ON $(Cr_2O_3)_{1-x}\cdot(Al_2O_3)_x$ SINGLE CRYSTALS.

S.Foner.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 63S-64S (March, 1961).

Results of pulsed field antiferromagnetic resonance (AFMR) experiments are briefly summarized for the mixed crystal system as a function of temperature, and of x, where x = 0.003, 0.006, 0.008, 0.06, 0.1, 0.2, and 0.9. The temperature dependence of the critical field, $(2\lambda K)^{\frac{1}{2}}$, for pure Cr_2O_3 and x = 0.1 are compared in detail. The increase of $(2\lambda K)^{\frac{1}{2}}$ at 4.2°K from about 59 kG for Cr_2O_3 to 79 kG for x = 0.1 is attributed to a reversal in sign and rapid increase in magnitude of the effective crystalline field contribution to the anisotropy energy as x is increased. AFMR line widths from 800 to 2000 G were observed, but for $x \leq 0.2$ the line width was almost independent of temperature for each composition. The decrease of Néel temperature with increase of x is also summarized.

6413 INFRARED ANTIFERROMAGNETIC RESONANCE IN MnO.

F.Keffer, A.J.Sievers III and M.Tinkham.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 65S-66S (March, 1961).

Antiferromagnetic resonance was observed in powdered MnO at 364 μ at 1.5°K. The resonance frequency as a function of temperature falls roughly as the square root of the Brillouin function of spin $\frac{5}{2}$. Fields of the order of 10^4 Oe have no observable effect on the line at 1.5°K. All of these results give quantitative confirmation of a model in which the sublattice magnetizations are constrained to a (111) plane by magnetic dipolar interactions and are held to a preferred direction within the plane by a much weaker anisotropy.

6414 PARAMAGNETIC RELAXATION RATES DETERMINED BY PULSED DOUBLE RESONANCE EXPERIMENTS.

B.Bölger and B.J.Robinson.
Physica (Netherlands), Vol. 26, No. 2, 133-41 (Feb., 1960).

The relaxation rates for synthetic ruby and $K_3Cr(CN)_6/K_3Co(CN)_6$ were determined for various Cr concentrations, magnetic field conditions and temperatures. In some cases it was possible to measure directly the cross relaxation rate. It is concluded that as the temperature is raised the Cr concentration in these salts can be increased without losing maser action.

PARAMAGNETIC RESONANCE IN STRAINED SEMICONDUCTING CRYSTALS. See Abstr. 6097

6415 PARAMAGNETIC RESONANCE FINE STRUCTURE SPECTRUM OF A CHROMIUM ION IN CHROME ALUM, INCORPORATING THE CALCULATION OF HIGH-ORDER TERMS.

A.M.Vasil'ev.
Fiz. tverdogo Tela (USSR), Vol. 2, No. 9, 2252-63 (Sept., 1960). In Russian.

For abstract, see Abstr. 21073 of 1960. [English translation in: Soviet Physics—Solid State (USA), Vol. 2, No. 9, 2009-18 (March, 1961)].

6416 EFFECT OF PLASTIC DEFORMATION ON THE WIDTH OF ELECTRON RESONANCE LINES.

A.A.Galkin and D.A.Kichigin.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 4, 767-8 (1958). In Russian.

Plastic deformation of lithium increased the line width to about 20 Oe from 10 Oe. By observing the rate of anneal at 293°K and 373°K an activation energy of 1500 cal/mole was obtained. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 4, 187-8 (1958)]. D.J.Oliver

6417 PARAMAGNETIC RESONANCE OF ^{8}S STATE IONS IN METALS.

M.Peter.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 338S-339S (March, 1961).

A study of the electron paramagnetic resonance spectrum in several intermetallic compounds containing either europium or gadolinium was made. These ions show very nearly the free ionic g value in their paramagnetic spectra in ionic crystals, indicating that only small admixtures of higher states to the free ionic ground state are caused by the crystalline perturbation. In metals there is, however, a contribution to the ionic g factor which can be attributed to the exchange interaction between the magnetic core and the conduction electrons. This contribution in $GdAl_2$ was measured. The effect was small and could only be identified after careful analysis of the observed line shapes and a correction for the magnetization of the samples. The sign of the exchange interaction is found to be negative, whereas such interactions are always positive in free ions. The interaction also gives rise to an indirect coupling with the other magnetic ions. The resonance lines are therefore exchange narrowed and of the Lorentz type. If other rare earths are substituted for some of the gadolinium then an additional broadening is observed from which the s-f interaction for all rare earths can be estimated.

6418 PARAMAGNETIC RESONANCE MEASUREMENTS OF EXCHANGE INTERACTIONS.

J.Owen.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 213S-217S (March, 1961).

A brief survey is given of some paramagnetic resonance experiments on exchange coupled pairs of paramagnetic ions in magnetically dilute crystals. The spin Hamiltonian for a pair of coupled sins S^i, S^j is first discussed. Then the effects observed in the paramagnetic resonance spectrum are outlined. Finally, there is a more detailed discussion of results found for nearest-neighbour and next-nearest-neighbour pairs of Mn^{2+} ions in Mn, MgO, followed by a short account of some preliminary results on nearest-neighbour pairs of Mn^{2+} ions in Mn, ZnF_2.

6419 CHROMIUM ION PAIR INTERACTIONS IN PARAMAGNETIC RESONANCE SPECTRUM OF RUBY.

H.Statz, L.Rimai, M.J.Weber, G.A.DeMars and G.F.Koster.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 218S-220S (March, 1961).

The paramagnetic resonance spectrum of Cr^{3+} pairs in ruby (with added Cr_2O_3) which interact via exchange and dipolar forces were studied at 15.74 kMc/s in the temperature range 1.2° to 700°K. Theoretical analysis predicts and experiments confirm that relatively distant neighbours with negligible exchange coupling give rise to resonance lines which cluster around isolated Cr^{3+} ion lines. Spin pairs coupled through exchange forces large as compare to the Zeeman or crystalline field energies give rise to lines that cluster around magnetic field values different from those for isolated Cr^{3+} lines. Exact calculations on an IBM 704 computer are used to assign lines in a given cluster to various neighbour pairs. This assignment together with the temperature dependence of the line intensities are used to determine the exchange forces. For nearest neighbours the exchange constant is 390 ± 50 cm^{-1} while the 3rd through 11th neighbour shells have exchange interactions of order 1 cm^{-1}. Spin-lattice relaxation is discussed for pairs coupled through anisotropic exchange or weak isotropic exchange forces.

6420 PARAMAGNETIC RESONANCE HYPERFINE STRUCTURE OF TETRAVALENT Pa^{231} IN Cs_2ZrCl_6.

J.D.Axe, H.J.Stapleton and C.D.Jeffries.
Phys. Rev. (USA), Vol. 121, No. 6, 1630-7 (March 15, 1961).

Paramagnetic resonance absorption at 3 cm wavelength was observed for tetravalent Pa^{231} in a single crystal of Cs_2ZrCl_6 at helium temperatures. The observed spectra correspond to the allowed transitions $(S_Z, I_Z \rightarrow S_Z \pm 1, I_Z)$ and the forbidden transition $(S_Z, I_Z \rightarrow S_Z \pm 1, I_Z \mp 1)$ of a system described by the spin Hamiltonian:

$$H_s = g\beta\vec{H}\cdot\vec{S} + A\vec{I}\cdot\vec{S} - g_n'\beta\vec{H}\cdot\vec{I},$$

with $S = \frac{1}{2}$, $I = \frac{3}{2}$, $|A|/h = 1578.6 \pm 1.4$ Mc/s, $|g| = 1.1423 \pm 0.0014$, and $|g_n'| \cong 8 \times 10^{-4}|$. The errors indicate a small deviation from isotropy. It is further observed that $g_n'/g < 0$, indicating that if g_n' is positive, as is strongly indicated by the nuclear shell model, then g is negative. An additional electron-nuclear double-resonanc experiment is used to determine directly the nuclear magnetic moment $\mu(Pa^{231}) = 1.96$ nuclear magnetons. This value includes a correction of 9% due to perturbations of an excited state about 1900 cm^{-1} above the ground-state doublet of Pa^{4+} in its octahedral crystal field. A lower frequency double-resonance experiment is used to measure the weak hyperfine interaction of the Pa^{4+} ion with its Cs^{133} neighbours, of order $A''/h \cong 0.5$ Mc/s.

6421 TRANSIENT EXCITATION OF NUCLEI IN FERROMAGNETIC METALS.

M.Weger, E.L.Hahn and A.M.Portis.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 124S-125S (March, 1961).

Free precession signals and spin echoes were observed from Fe^{57}, Co^{59} and Ni^{61} nuclei in finely divided multidomain iron, cobalt, and nickel, respectively. Spin—lattice relaxation was studied in all three metals from temperatures in the liquid helium range to room temperature or above. Although the relaxation is not strictly exponential, the rate of recovery of the magnetization appears to be proportional to the absolute temperature. Spin—spin relaxation was studied in natural cobalt and in both natural and enriched samp of iron and nickel. The spin-spin coupling is very much stronger in cobalt then in iron or nickel, as expected, because of the very much larger nuclear magnetic moment of Co^{59}. Spin diffusion through the frequency spectrum of cobalt was investigated at 4.2 and 77°K by the stimulated echo technique. The results are consistent with a theory of one-dimensional diffusion with exchange rate and exchang distance of the order of $1/T_2$. The spin-echo technique was also used on all three metals to study the effect of domain wall motion on the nuclear resonance. A d.c. pulse, which displaces the domai walls by a controllable amount, is placed between the first r.f. pulse and the echo. This study confirms that the induction signals arise from nuclei in domain walls and further suggests a connectio between line broadening and domain wall processes. A weak free-precession signal, arising from domain rotation, was observed fro cobalt in high magnetic fields. The sign of the precession was determined, confirming that the hyperfine field is directed opposite to the magnetization.

6422 SPIN—LATTICE RELAXATION TIMES IN SAPPHIRE AND CHROMIUM-DOPED RUTILE AT 34.6 Gc/s.

J.H.Pace, D.F.Sampson and J.S.Thorp.
Proc. Phys. Soc. (GB), Vol. 74, Pt 2, 257-60 (Feb., 1961).

The paper describes measurements made at 34.6 Gc/s on synthetic sapphire (Fe^{3+} in Al_2O_3) and chromium-doped rutile (Cr^{3+} in TiO_2) in the temperature range 1.4°K to 56°K. Spin—lattic relaxation times of up to 5 milliseconds at helium temperatures ar reported. The main features of the temperature dependence of the relaxation times show a broad similarity with the results previousl eported by the authors for ruby, but there are insufficient data to how whether the relaxation times are substantially independent of equency as was found for ruby.

6423 SPIN–LATTICE RELAXATION IN CERIUM MAGNESIUM NITRATE AT LIQUID HELIUM EMPERATURE: A NEW PROCESS.

.B.P.Finn, R.Orbach and W.P.Wolf.
roc. Phys. Soc. (GB), Vol. 77, Pt 2, 261-8 (Feb., 1961).

The spin–lattice relaxation time of Ce^{3+} in cerium magnesium itrate was measured as a function of temperature and of magnetic elds up to 1000 gauss. In the temperature range between 3° and .9°K, the relaxation time was found to vary exponentially with nverse temperature, changing by a factor of 350. A theoretical reatment of spin–lattice relaxation appropriate to rare earth alts leads to predictions which agree both with the experimentally bserved temperature dependence and with the magnitude of the elaxation time. The dominant relaxation process is one in which phonon of high energy ($\gg kT$) is absorbed by the spin system esulting in a transition from one of the ground-state doublet levels the nearest excited level. Then, in a separate step, another high-nergy phonon is emitted and a transition is effected to the other evel of the ground state doublet. The net result of this "two-step irect process" can be interpreted as spin–lattice relaxation; i.e. here results a net change in population between the ground state oublet levels which brings the spin system towards thermal quilibrium with the lattice. Such a mechanism, which is quite ifferent from those which have been envisaged up to now for pin–lattice relaxation, should be appropriate for many of the rare arth salts.

SIMULTANEOUS ABSORPTION BY SPIN SYSTEMS OF A ICROWAVE PHOTON AND AN ULTRASONIC PHONON. See bstr. 6071

6424 THE OVERHAUSER EFFECT IN METALS CONTAINING PARAMAGNETIC IMPURITIES. L.L.Buishvili.

iz. tverdogo Tela (USSR), Vol. 2, No. 9, 2268-9 (Sept., 1960). In ussian.

For abstract, see Abstr. 1274 of 1961. [English translation in: oviet Physics—Solid State (USA), Vol. 2, No. 9, 2023-4 (March, 1961)].

6425 MAGNITUDE OF NUCLEAR POLARIZATION IN THE TRANSIENT OVERHAUSER EFFECT. V.I.Avdeev.

ptika i Spektrosk. (USSR), Vol. 9, No. 6, 793-4 (Dec., 1960). n Russian.

Gives a calculation of nuclear orientation for the case of onsecutive saturation of two allowed transitions $\Delta M = \pm 1$, $\Delta m = 0$, here M and m are projections of the electron and nuclear spin long the field axis. This transient effect was used by Pines, ardeen and Slichter (Abstr. 5727 of 1957) to explain an observed ise of intensity of one line when its neighbour is saturated. English translation in: Optics and Spectrosc. (USA), Vol. 9, No. 6, 18-19 (Dec., 1960)]. A.Tybulewicz

6426 QUADRUPOLE–QUADRUPOLE INTERACTION IN THE RARE EARTHS. B.Bleaney.

roc. Phys. Soc. (GB), Vol. 77, Pt 1, 113-15 (Jan., 1961).

Electric quadrupole interactions of Ce^{3+} in cerium ethyl ulphate are analysed. It is shown that, contrary to previous work Abstr. 3502 of 1953), there are first-order effects arising from the nteractions. These should be detectable spectroscopically by bservation at millimetre wavelengths of the transition between X nd Y doublets (the $^2F_{5\,2}$ state of the Ce^{3+} ion is split by the crystal ield into three doublets which are labelled X, Y and Z, the states eing characterized to a good approximation by $J = \pm\frac{5}{2}, \pm\frac{1}{2}, \pm\frac{3}{2}$). he importance of the results derived is discussed generally, and ith particular reference to the lanthanon metals, UO_2 and NpO_2. S.A.Ahern

6427 THE INFLUENCE OF THE TUNNEL TRANSITION ON THE FORM OF THE LINE SIGNAL OF NUCLEAR MAGNETIC ESONANCE IN CRYSTALS. I.V.Aleksandrov.

okl. Akad. Nauk SSSR, Vol. 133, No. 5, 1057-9 (Aug. 11, 1960). In ussian.

For abstract, see Abstr. 1279 of 1961. [English translation in: oviet Physics—Doklady (USA), Vol. 5, No. 4, 837-9 (Jan.-Feb., 961)].

6428 ACOUSTIC EXCITATION OF FREE NUCLEAR INDUCTION IN CUBIC CRYSTALS.

.G.Koloskova and U.Kh.Kopvillem.
z. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 818-24 ec., 1960). In Russian.

Proves theoretically the possibility of detection of a nuclear magnetic induction signal due to ultrasonic pulses. The intensity and profile of the signal are calculated. A new method is given for direct measurement of the nuclear spin–lattice interaction in crystals. It is shown that an acoustic pulse causes oscillations of the non-equilibrium macroscopic components of the tensor of the electric quadrupole moment of the spin system. A.Tybulewicz

6429 NUCLEAR POLARIZATION IN METALLIC LITHIUM. N.A.Bekeshko and Ye.I.Kondorskiy.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 4, 609-13 (1958). In Russian.

A standard apparatus is described for observing the enhancement of the nuclear resonance signal by saturating the electron spin resonance in a static magnet field of 30 Oe. Details are given for the preparation of colloidal suspensions of metallic lithium (particle size $< 15\ \mu$). The results obtained agree with previous ones (Abstr. 8940 of 1952). Further results are described in another paper (Abstr. 721 of 1958). [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 4, 30-4 (1958)]. D.J.Oliver

6430 FINE STRUCTURE OF THE NUCLEAR MAGNETIC RESONANCE SPECTRA OF SOLIDS: CHEMICAL SHIFT STRUCTURE OF THE SPECTRUM OF PHOSPHORUS PENTACHLORIDE. E.R.Andrew, A.Bradbury, R.G.Eades and G.J.Jenks.

Nature (GB), Vol. 188, 1096-7 (Dec. 24, 1960).

The technique for improving the resolution in a solid sample by spinning it at high speed is discussed. The application of this method to the determination of the chemical shift of P^{31} in solid PCl_5 is described. D.J.Oliver

6431 N.M.R. AND THE CONDUCTION ELECTRON POLARIZATION IN RARE EARTH METALS. V.Jaccarino.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 102S-106S (March, 1961).

The magnitude and sign of the conduction electron polarization in rare-earth intermetallic compounds was determined with the use of n.m.r. techniques. Large, temperature-dependent Knight shifts of the Al^{27} n.m.r. were found in XAl_2 (X ≡ rare-earth ion). These observations may be explained by assuming that a negative exchange interaction of ~0.1 eV exists between the localized f electrons of the rare-earth ion and the conduction electrons.

6432 PRESSURE AND TEMPERATURE DEPENDENCE OF THE Fe^{57} NUCLEAR MAGNETIC RESONANCE FREQUENCY IN FERROMAGNETIC IRON.

G.B.Benedek and J.Armstrong.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 106S-110S(March, 1961).

The pressure dependence of the Fe^{57} nuclear magnetic resonance frequency ν in ferromagnetic iron was measured from 1 to 10 000 kg/cm² at −77°C, 0°C, and 84.2°C. From these measurements the volume dependence of ν was obtained, enabling the correction of measurements of $\nu(T)$ at P = 1 atm, for the effects of thermal expansion. By making a similar correction for the effect of thermal expansion on the temperature dependence of the saturation magnetization σ, it was found that at constant volume, the hyperfine coupling constant A in the relation $\nu = A\sigma$ is an explicit function of the temperature. Thus, measurements of the temperature dependence of ν, even when corrected to constant volume, do not give accurately the temperature dependence of σ. The results of a theory based on Stoner's collective electron model for the d electrons are presented to account for the temperature dependence of A.

6433 NUCLEAR MAGNETIC RESONANCE OF Fe^{57} IN UNENRICHED Fe.

J.I.Budnick, L.J.Bruner, R.J.Blume and E.L.Boyd.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 120S-121S (March, 1961).

The nuclear magnetic resonance of Fe^{57} was observed in iron specimens in the form of powders of various sizes, foils, and whiskers. Results are consistent with previously reported work of Gossard, Portis, and Sandle on enriched iron, and with the work of Robert and Winter on natural iron. It is found that the resonant frequency varies slightly among nominally pure iron specimens taken from different sources, suggesting that it is somewhat sensitive to impurity content. Prestrain of the specimen has a marked effect, the resonance in cold-rolled foil being very broad and weak compared to that observed in annealed foils. Observations of nuclear magnetic resonance in iron whiskers oriented both axially and transversely in the r.f. coil offer interesting confirmation of the domain wall enhancement mechanism put forth by Gossard and Portis. The temperature dependence of the Fe^{57} resonance was investigated in the range 77°-785°K.

6434 NUCLEAR RESONANCES IN CUBIC, HEXAGONAL, AND MIXED PHASE COBALT POWDERS AND THIN FILMS.

W.A.Hardy.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 122S-123S (March, 1961).

A number of nuclear resonances in ferromagnetic cobalt are reported and identified as originating in h.c.p. crystallographic structure and in associated fault structure. A tentative assignment of these lines has been made to possible stacking fault symmetries by correlating the observed resonances with metallurgical sample treatments.

6435 NUCLEAR MAGNETIC RESONANCE IN NiF_2 DOMAIN WALLS.

R.G.Shulman.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 126S-128S (March, 1961).

Two additional nuclear resonances of the F^{19} nuclei are observed in the antiferromagnetic state of NiF_2. These resonances can be observed in zero magnetic field at $\nu = 26.6$ Mc/s and $\nu = -51.2$ Mc/s. They are broad, asymmetric and easily saturated,with an apparent value of $T_1 \sim 8$ sec, at 20.30°K. They correspond to internal fields along $[110]$ and $[\bar{1}\bar{1}0]$ directions respectively for H_0 along $[110]$. These compare quite well with the theoretical values of +18.7 Mc/s and −54.4 Mc/s calculated from the measured interaction parameters for a spin alignment along $[110]$ and $[\bar{1}\bar{1}0]$. These two resonances arise from F^{19} nuclei in the domain walls.

6436 MAGNETIC RESONANCE OF PROTONS IN GLASSES.

D.Elwell, D.Kumar and D.Williams.
Nature (GB), Vol. 188, 1103-4 (Dec. 24, 1960).

Nuclear resonance is used for estimating the water content of various glasses, the minimum detectable concentration being 0.25%.

D.J.Oliver

6437 PROTON MAGNETIC RESONANCE STUDIES OF STRUCTURE, DIFFUSION, AND RESONANCE SHIFTS IN TITANIUM HYDRIDE.

B.Stalinski, C.K.Coogan and H.S.Gutowsky.
J. chem. Phys. (USA), Vol. 34, No. 4, 1191-1206 (April, 1961).

Measurements of the proton magnetic resonance at ~26.9 Mc/s in titanium hydride samples, ranging in composition from $TiH_{1.61}$ to $TiH_{1.97}$, were made in the temperature range from -196° to about 200°C. The second moment of the proton resonance at the lower temperatures shows that the hydrogen atoms are randomly distributed among the lattice sites which are located tetrahedrally with respect to the titanium atoms. Self-diffusion of the hydrogen atoms narrows the proton resonance above room temperature. The temperature dependence of the correlation frequency for the proton motions, obtained from the linewidths, leads to diffusional activation energies which increase with hydrogen content from 9.4 kcal/g atom for $TiH_{1.607}$ to 10.2 for $TiH_{1.923}$. Morever, the diffusion rate is directly proportional to the number of unfilled tetrahedral holes in the metallic lattice, which indicates that the self-diffusion takes place via a vacancy mechanism. Proton resonance shifts to higher applied magnetic fields were observed. They were measured at room temperature for all specimens and were found to increase from 0.01% for $TiH_{1.607}$ to about 0.032% for $TiH_{1.969}$. For these two extreme compositions, the temperature dependence of the shift was measured between -95°C and 190°C and was found to be similar to the bulk susceptibility, the shifts for $TiH_{1.969}$ exhibiting an anomaly at about 13°C as does the susceptibility. These results are interpreted semiquantitatively in terms of exchange interactions which pair spins of electrons in the conduction band with those of electrons localized on the hydrogen. The results suggest that the hydrogen is held in the lattice by a combination of covalent and ionic bonding, the latter involving a net positive charge on the hydrogen. The general importance of exchange interactions in intermetallic compounds is commented upon.

6438 IMPURITY SHIFT OF PURE QUADRUPOLE RESONANCE FREQUENCY.

Y.Imaeda.
J. Sci. Hiroshima Univ. A (Japan), Vol. 24, No. 2, 239-85 (Oct., 1960).

The pure quadrupole resonance frequency of Cl^{35} in $KClO_3$ and $NaClO_3$ and that of Br^{81} in $KBrO_3$ and $NaBrO_3$ were found to shift slightly when small amounts of impurities were introduced into the lattice of the specimens. An increase in the line width and a decrease in the intensity of the lines were also observed. The sign of the frequency shift was either positive or negative according to the kind of impurities. The general rule for this sign was that the larger impurity decreases the frequency (– sign) and the smaller impurity increases the frequency (+ sign). The intensity measurements gave an estimate of the critical numbers of impurities. The lines were always Gaussian in shape and no asymmetry was observed in any specimens. Theories of the impurity shift are developed. The shifts are attributed mainly to the charge-transfer effects. An extension of the general theory of the effect of the lattice vibration on the quadrupole resonance frequency is also presented.

MECHANICAL PROPERTIES OF SOLIDS

6439 DEFORMATION ANISOTROPY.

B.A.Berg.
Priklad. Mat. i Mekh. (USSR), Vol. 22, No. 1, 67-77 (1958). In Russian.

A study is made of the anisotropy which develops in a body as a result of its elastic deformation. The case is considered of a body which, from its "natural" state, is subjected to two consecutive elastic deformations. It is shown that, if the first deformation is homogeneous and different from a hydrostatic tension or compression, then upon the application of the second deformation, the body deforms (in general) as an orthotropic one. The principal directions of elasticity coincide with the principal axes of the homogeneous deformation, and the elastic constants of the deformed body can be expressed in terms of the elastic constants of the original isotropic body and its principal elongations in the first deformation. As examples, the torsion of an elongated bar and the bending of an extended and sheared plate are considered.

6440 ORIENTATIONAL MISALIGNMENTS IN THE DETERMINATION OF THE ELASTIC CONSTANTS OF CUBIC CRYSTALS.

E.S.Rajagopal.
J. sci. industr. Res. (India), Vol. 20B, No. 2, 50-2 (Feb., 1961).

A method for evaluating the elastic constants of cubic crystals from the velocities along arbitrary directions is described and expressions are derived for the velocities near the cubic, octahedral and dodecahedral directions. The errors due to the misalignments are discussed and it is shown that the transverse waves near the octahedral direction are susceptible to large misalignment errors.

6441 A THIN FILM RESISTOR FOR MEASURING STRAIN.

G.Siddall and G.Smith.
Vacuum (GB), Vol. 9, 144-6 (May, 1959; publ. Dec., 1960).

An investigation has been made into the measurement of mechanical strain in terms of the electrical resistance changes induced in an evaporated metal film on a flexible support cemented to a stressed surface. The results show that a polyester foil coated with a nickel-chromium alloy is suitable for short-term measurement purposes.

STRESS ANALYSIS BY MAGNETIC METHODS. See Abstr. 6250

6442 ELASTIC AND PHOTOELASTIC CONSTANTS OF CRYSTALS.

R.S.Krishnan, V.Chandrasekharan and E.S.Rajagopal.
Indian Institute of Science Golden Jubilee Research Volume (see Abstr. 2678 of 1961) p. 150-62.

The basic features of the various theories of crystal elasticity are discussed and a critical survey of the available experimental and theoretical evidences in favour of the various theories is made. In order to test the validity or otherwise of the various theories certain clear-cut experiments have been suggested using such simple crystals like magnesium oxide, zinc sulphide, diamond, sodium chlorate and bromate, nitrates of barium, strontium and lead, ice, beryl, quartz, tourmaline, ammonium and potassium dihydrogen phosphates, magnesium and zinc sulphates, etc. The effect of the new theories on the photoelastic behaviour of crystals is also discussed.

6443 ON THE MEASUREMENT OF c_{13} IN RHOMBOHEDRAL CRYSTALS.

L.J.Teutonico.
J. appl. Phys. (USA), Vol. 32, No. 1, 119 (Jan., 1961).

A theoretical analysis is given for the determination of the third pure mode axis in a rhombohedral crystal, the first two mode axes being the axis of 3-fold symmetry and any one of the 3 axes in the base plane normal to a mirror plane. The third mode axis is located to within an accuracy of fifteen degrees. The predictions are compared with experiment by using the measured values of the elastic constants for calcite, bismuth, antimony and sapphire.

R.Bullough

6444 ELASTIC CONSTANTS OF AMMONIUM DIHYDROGEN PHOSPHATE (ADP) AND THE LAVAL THEORY OF CRYSTAL ELASTICITY. H.Jaffe and C.S.Smith.
Phys. Rev. (USA), Vol. 121, No. 6, 1604-7 (March 15, 1961).

The acoustic shear-wave velocities v_{yz} were measured in ADP by the direct method of piezoelectric resonances, and by the direct pulse-echo method. These velocities are found with each method to be equal within the experimental uncertainty. The resonance results have a probable error of 0.1% for the difference between the corresponding Laval elastic constants c_{44} and c_{77}. This experimental result disagrees with those previously obtained with ADP by indirect methods.

6445 AN INTERNAL FRICTION PEAK OBSERVED DURING TESTS ON DEFORMED ALUMINIUM.
D.M.Ibragimova and A.I.Moiseev.
Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 5, 952-4 (1958).
In Russian.

Limited data is presented for the variation with decreasing temperature (from 600°C) of the internal friction of 99.99% pure Al cold reduced by roughly 80%. An additional peak appears at 500°C in the internal friction versus temperature plot compared with annealed material; brief comparison is effected of results on rising and falling temperature tests. No interpretation of the results is attempted. 12 references. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 5, 185-7 (1958)]. J.W.Taylor

6446 LOW-TEMPERATURE STRESS-RELAXATION PEAKS IN PLASTICALLY DEFORMED POLYCRYSTALLINE NIOBIUM. R.H.Chambers and J.Schultz.
Acta metallurgica (Internat.), Vol. 8, No. 8, 585-7 (Aug., 1960).

Internal friction measurements were made on niobuim bars over the temperature range 4° to 300°K using alternating stresses with frequencies between 10 and 100 kc/s and amplitudes varying from 10^{-8} to 10^{-4}. The main absorption peak was centred at about 167°K and the magnitude varied with the amount of pre-strain given to the specimens, a maximum occurring at 3% pre-strain. Annealing experiments were carried out and it is suggested that annealing causes the migration of gaseous interstitials to dislocation lines thus pinning them. Oxygen is probably the diffusing element, since the activation energy for diffusion in niobium is about equal to 1 eV, the estimated activation energy for annealing. The dependence of the internal friction on the strain amplitude and the strength of the main peak on the total strain are consistent with the dislocation model proposed. A.E.Kay

6447 SOME EFFECTS OF DIRECTIONAL ORDERING IN ZONE-MELTED IRON. R.E.Maringer.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 366S-367S (March, 1961).

The effects of C and N in iron were studied with the use of both mechanical and magnetic methods. Internal-friction techniques were used to follow the magnetoelastic after-effect, and showed the existence of a peak in the magnetoelastic damping near the Snoek peaks. At higher frequencies, the effects of directional ordering were observed with a transformer-type device, the internal-friction specimen acting as the core. Relaxation times calculated from the magnetoelastic data are in good agreement with published data, while relaxation times calculated from the magnetic peaks and from the transformer data are not. Reasons for this apparent discrepancy are discussed.

6448 THE BORDONI EFFECT IN SILVER-GOLD ALLOYS.
I.Barducci, M.Nuovo and L.Verdini.
Nuovo Cimento (Italy), Vol. 19, No. 4, 653-6 (Feb. 16, 1961).
In Italian.

Experiments carried out in the alloys of the Ag—Au system showed the existence of the Bordoni peak (Abstr. 9020 of 1954) in a temperature range between 71.5°K (pure silver) and 132°K (pure gold), for a vibration frequency of about 20 kc/s. The peak was clearly exhibited by the alloys with a small concentration of foreign atoms, but it was reduced to a nearly flat curve when the atomic concentration approached the one to one ratio. The experimental curve of the extensional velocity measured at room temperature and that of the velocity temperature coefficient β measured at 293°K and 77°K, showed anomalous behaviour for atomic concentrations of gold less than 10%. These effects are related to a high number of active dislocations present in the specimens. For alloys containing more than 10% of gold, the velocity curve is concave towards the concentration axis. The activation energy W for the alloys has not yet been measured directly. An estimate for the values of W was however, obtained assuming that the curve of W as a function of concentration is not a straight line, but a curve with its concavity towards the abscissa as it is suggested by the negative deviation from the Vegard's law shown by the lattice constant of the Ag—Au system.

6449 THE RELAXATION PHENOMENA OF HIGH POLYMER SUBSTANCES.
Suppl. Progr. theor. Phys. (Japan), No. 10, 1-239 (1959).

Fifteen papers were read at a meeting held on November 17-22, 1958, at the Research Institute for Fundamental Physics, Japan. Abstracts of the papers will appear in subsequent issues of Physics Abstracts.

6450 RUBBER MODELS OF YARNS AND CORDS; THE "DOUBLING" OF SINGLE RODS.
N.Wilson and L.R.G.Treloar.
Brit. J. appl. Phys., Vol. 12, No. 4, 147-54 (April, 1961).

The paper is concerned with the calculation and measurement of the stresses involved in the twisting together of two cylindrical rubber rods, which may be taken as a model of a two-ply cord. Two cases were examined: in the first the rods are initially without twist, while in the second they contain initial twist. The forces measured are the couple about the "cord" axis and the tension along this axis, as functions of "cord" twist and "cord" axial extension. The forces are calculated on the basis of Rivlin's equations for the stresses in a rubber cylinder subjected to combined axial extension and torsion, corrections being introduced for the effects of lateral pressure between "plies" on the tensile force, the noncircularity of section resulting from this lateral pressure on the couple due to torsion and bending, and for the effect of torsion on the bending couple. For the case of zero initial twist in the rods the agreement between calculated and observed forces is good. When initial twist is present, however, there are significant differences, which are not fully understood.

6451 X-RAY OBSERVATION OF THE STRAIN FIELD IN GERMANIUM SINGLE CRYSTALS WITH THE USE OF ANOMALOUS TRANSMISSION. Z.Ishii and K.Kohra.
J. Phys. Soc. Japan, Vol. 14, No. 9, 1250-1 (Sept., 1959).

Work similar to Hunter (Abstr. 8912 of 1959) is reported on crystals deformed with a wedge and by bending. J.E.Caffyn

6452 ON THE TEMPERATURE DEPENDENCE OF FLOW STRESS IN QUENCHED ALUMINIUM CRYSTALS.
L.E.Tanner.
Acta metallurgica (Internat.), Vol. 8, No. 10, 730-2 (Oct., 1960).

Earlier workers have found a difference in flow stress when specimens, in the annealed state, were deformed to the same strain at different temperatures. They attributed this result to dislocations resulting from thermal assistance and to variations of the dislocation configuration with temperature. High-purity single crystals of aluminium were subjected to cycling tests at a number of temperatures between 78 and 293°K. Quenched crystals behaved precisely similarly to fully annealed ones. The flow stress was found independent of the increase of dislocation density resulting from quenching. It was concluded that, despite the extreme changes in the deformation process resulting from quenching, certain areas remain unaffected. It was then suggested that the "forest" effect is important in explaining the mechanical behaviour of aluminium crystals independent of prior thermal history. A.C.Whiffin

6453 DISCUSSION OF WILLIAMS' COMMENTS ON "THE INFLUENCE OF GRAIN SIZE ON THE STORED ENERGY AND MECHANICAL PROPERTIES OF COPPER". I-II.
L.M.Clarebrough, M.E.Hargreaves and M.H.Loretto; J.F.Nicholas.
Acta metallurgica (Internat.), Vol. 8, No. 10, 736, 737 (Oct., 1960).

In rebuttal of Williams's comments (Abstr. 21132 of 1960) Clarebrough, Hargreaves and Loretto state that Williams plotted their results incorrectly and that his criticism of inaccuracy was unfounded.

Nicholas gives a further rebuttal claiming the incorrect use of an equation by Williams and setting out the preferred treatment. J.Thewlis

6454 THE LOW TEMPERATURE TENSILE PROPERTIES OF NIOBIUM. A.A.Johnson.
Acta metallurgica (Internat.), Vol. 8, No. 10, 737-40 (Oct., 1960).

The tensile yield stress of body-centred cubic metals has been shown to vary with grain diameter according to a formula involving the lattice friction stress and the dislocation unlocking stress. The grain size dependence of the tensile properties of niobium was determined at a series of low temperatures to obtain the temperature dependence of the lattice friction stress and the dislocation unlocking stress. Rods 0.05 in. and 0.10 in. in diameter by 0.75 in. long were tested at 76, 195 and 293 °K. The yield stress was found independent of grain size at each temperature, but decreased with rise of temperature. It was concluded that the dislocations were not appreciably locked by impurity atoms. A.C.Whiffin

6455 A YIELD PLATEAU IN IRON AFTER DEFORMATION AGEING. B.I.Smirnov.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 763-6 (Nov., 1960). In Russian.

If deformed iron was stored for some time, a yield plateau appeared on subsequent deformation; this was not observed in a freshly prepared sample. The effect is known as deformation ageing. It was found in Armco iron and the paper explains it in terms of dislocations and their motion. A.Tybulewicz

6456 THE EFFECT OF PLASTIC DEFORMATION ON THE PHASE COMPOSITION OF STEEL ALLOYED WITH Cr AND Mn. B.A.Apaev and Yu.A.Sysuev.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 767-71 (Nov., 1960). In Russian.

Deformation of steel alloyed with Cr and Mn and having the structure of α-phase and cementite mixture, produced complex phase transformation which strongly depended on the degree of alloying of cementite. A.Tybulewicz

EFFECT OF PLASTIC DEFORMATION ON THE WIDTH OF ELECTRON RESONANCE LINES. See Abstr. 6416

6457 STUDY OF INITIAL CONDITIONS IN CONSTANT VELOCITY IMPACT. J.F.Bell.

J. appl. Phys. (USA), Vol. 31, No. 12, 2188-95 (Dec., 1960).

Diffraction grating measurements of dynamic plastic strain were made within a few thousandths of an inch from the impact face of 1 in. diameter, annealed aluminium rods in free flight undergoing constant velocity impact. From these data it was established that initial nondispersive shock fronts are present, even in low-velocity impact. This initial nondispersive front develops in the first $\frac{1}{4}$ diameter in two sections, each involving half the initial kinetic energy; the first section is that of the deviatoric, or shear, component, and the second is associated with the hydrostatic stress. It is shown that the dynamic stress—strain curves obtained experimentally in annealed aluminium and copper may be computed directly from the theory, using information supplied by the static stress—strain curve. The von Karman critical velocity for annealed aluminium is found to be a dividing point between two types of initial wave development.

6458 ON THE THEORY OF STRIP ROLLING. A.Troost.

Naturwissenschaften (Germany), Vol. 47, No. 16, 373-4 (1960). In German.

A note on the quasilinear method for the solution of the differential equation of strip rolling. The calculated results are compared with results of other workers for cold rolled aluminium and for hot rolled steel. T.C.Toye

6459 THE PLASTIC INDENTATION OF A SEMI-INFINITE SOLID BY A PERFECTLY ROUGH CIRCULAR PUNCH. G.Eason and R.T.Shield.

Z. angew. Math. Phys. (Switzerland), Vol. 11, No. 1, 33-43 (Jan. 25, 1960).

A continuation of an earlier paper [Proc. Roy. Soc. A, Vol. 233, 267 (Dec., 1955)] which considered the general problem of plastic flow of metals under conditions of axial symmetry for the Tresca yield criterion and associated plastic stress—strain relations. The basic equations are restated and the hypothesis of Haar and von Karman that the circumferential stress is equal to one of the principal stresses in the meridional plane during plastic deformation is assumed. The stress field and an incipient velocity field are worked out and the average indentation pressure is deduced from them. This comes out as 6.05 k, where k is the maximum shear stress which can be supported. The solution applies if the coefficient of friction exceeds 0.139. A.E.Kay

6460 THE GENERALIZED PLANE STRAIN OF AN ELASTO-PLASTIC MATERIAL. D.R.Bland.

Z. angew. Math. Phys. (Switzerland), Vol. 10, No. 2, 113-33 (March 25, 1959).

The equations for the stresses and velocities in elasto-plastic solids are considered generally, on the assumptions of generalized plane strain and a Tresca yield condition, taking into account temperature variations and distinguishing non-hardening and linear work-hardening materials. In the work-hardening case, the differential equations that have to be solved are elliptic in the plastic, as well as in the elastic, regions. Some simple solutions in terms of a stress function, in cases where the form of the plastic-elastic interfaces is obvious, are indicated briefly. J.G.Oldroy

6461 A CORRELATION BETWEEN THE RATE OF CREEP AND THE LIFETIME OF A METAL UNDER LOAD. B.Ya.Pines and A.F.Sirenko.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 382-9 (Sept., 1960). In Russian.

It was found that the product of the steady-state rate of creep, v, and the lifetime of a metal under load, τ, is constant in the case of copper, nickel, iron, tin, and lead, only for large applied loads. With decrease of the applied load the product $v\tau$ rose rapidly. An explanation of these phenomena is given. A.Tybulewicz

6462 SOME FEATURES OF CREEP IN STEEL. B.M.Rakhman, A.Ya.Madorskii and V.V.Obukhovskii.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 617-21 (Oct., 1960). In Russian.

Creep and failure under load were studied at 500-750 °C in austenitic steel (10-12.5% Cr, 18-21% Ni, 2.6-3.2% Ti). The observed behaviour was ascribed to decomposition of the solid solution confirmed by measurements of the lattice constant and the electrical conductivity. A.Tybulewicz

6463 CREEP AND STRESS RELAXATION IN ALPHA-BRASS AT LOW TEMPERATURES. P.Feltham.

Phil. Mag. (GB), Vol. 6, 259-70 (Feb., 1961).

Creep of vacuum-annealed polycrystalline 65/35 alpha-brass was studied at constant stress in the range 77-300 °K, close to the yield point, at elongations not exceeding 3%. The tensile strain ϵ increased logarithmically with time, and the characteristic strain $s_{cr} \equiv d\epsilon/d\log_{10}t$, given by the slope of the creep curves in semi-logarithmic representation, decreased approximately linearly with increasing temperature, from 29×10^{-4} at 77 °K to 11×10^{-4} at 300 °K. The creep was correlated with logarithmic stress relaxation, and the relation $s_{cr} = -s_{rel}/\chi$ was established, where $\chi \equiv d\sigma/d\epsilon$ is the coefficient of work-hardening, and $s_{rel} \equiv d\sigma/d\log_{10}t$ the slope of the corresponding curve obtained with stress relaxation at constant elongation. Both the creep and the relaxation are ascribed to a process of residual slip propagation in which the migration of edge dislocations impeded by the drag of conservatively moving jogs is rate determining. The driving force on the jog is the component of the line tension of the dislocation, which impels the jog in the direction of its Burgers vector; the effective stress on the dislocation is the difference between that necessary to tear it from its locked site and the stress due to the intragranular sub-structure, which opposes its movement through the lattice in the unlocked state. At temperatures exceeding about 300 °K, when dislocation locking is weak, both s_{cr} and s_{rel} tend to very small values.

6464 OBSERVATIONS ON THE WORK-HARDENING OF ZINC CRYSTALS IN ALTERNATING TENSION AND COMPRESSION. D.S.Kemsley.

Acta metallurgica (Internat.), Vol. 8, No. 10, 740-3 (Oct., 1960).

The hardening behaviour of single crystals of Zn in which only one set of slip planes is usually operative, was studied at two amplitudes of alternating straining and in tension. Four orientations were studied. Reversed straining at an amplitude of 0.0001 glide per half cycle showed a low rate of hardening which was similar for each orientation. Tests at an amplitude of 0.02 at the same rate of straining showed a similar linear hardening rate but a greater initial hardening. Recovery had a strong influence on the stress—glide curves, the hardening rate being greater when the test was carried out at a higher strain rate. No yield occurred in any test, but, from the departure from elastic strain, it was inferred that the critical resolved shear stress was 9 g/mm². It was concluded that at greater amplitudes of glide, hardening increases and slip becomes more prominent, possibly due to dislocation interaction between the primary slip direction and a secondary direction in the slip plane, or to participation of a second plane of non-basal type. Some form on non-basal slip might be expected in hexagonal metals during fatigue. A.C.Whiffi

6465 THE EFFECT OF THE DIRECTION OF SLIDING ON THE [FRICTION-INDUCED] WORK HARDENING OF THE SURFACE LAYERS. V.D.Evdokimov.

Dokl. Akad. Nauk SSSR, Vol. 136, No. 1, 74-6 (Jan. 1, 1961). In Russian.

A steel ring with its cylindrical face pressing against flat, olycrystalline specimens of aluminium and other metals, or gainst the (100) plane of a rocksalt monocrystals, was rotated at peripheral speed of 2 m/min, and the resultant work hardening f the surface layers of the specimens, both inside and outside the one of contact, was studied by measurement of microhardness and islocation density. Similar experiments were carried out with he direction rotation of the steel ring being reversed after each evolution. In the former case, the degree of surface work hardening of all the materials varied across the zone contact, being lowest n the region where tensile tangential forces predominated, and owest in the zone of compression. The effect of friction loading xtended beyond the area of the contact zone, the degree of work ardening and the area affected being again greater on the comression side. The surface layers in the contact zone of specimens, ested under conditions of periodically reversed direction of sliding, ork-hardened uniformly. The degree of work hardening was lower han that due to unidirectional friction and so was the extent of work ardening outside the contact area. This fact may explain the elatively higher rate of wear of machine parts operating under onditions of alternating frictional loads. [English translation in: oviet—Doklady (USA)]. M.H.Sloboda

6466 THEORETICAL STRENGTH AND CRITICAL RUPTURE STRESS OF SOLIDS.

G.M.Bartenev and I.V.Razumovskaya.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 341-4 (July 11, 1960). In Russian.

For abstract, see Abstr. 16233 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 857-60 (Jan.-Feb., 1961)].

6467 EXPERIMENTAL INVESTIGATION OF LIMITING CARRYING CAPACITY OF NICKEL TUBES FOR DIFFERENT LOAD APPLICATIONS: TENSILE STRESSES, SHEAR MOMENTS AND INTERNAL PRESSURES.

N.Ya.Mikhailov and Yu.I.Yagn.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 3, 545-8 (Nov. 21, 1960). In Russian.

Tubes of isotropic nickel were loaded by a single stress application or by a compound application (when one kind of stress was first gradually applied until it reached limiting value, following which another kind of stress was applied). The results are tabulated and the strains show good agreement with the third and the fourth criteria of elasticity. The Lankford and Saibel criteria [Metals Technology (USA), Vol. 14, No. 5, 1947] for simultaneous application of tensile stresses and of internal pressures are also verified. [English translation in: Soviet Physics—Doklady (USA)]. J.K.Skwirzynski

6468 STRENGTH AND HARDNESS OF TWO-PHASE CERMET ALLOYS OF TITANIUM CARBIDE WITH TUNGSTEN CARBIDE AND COBALT.

G.S.Kreimer, M.R.Vakhovskaya and A.I.Baranov.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 698-709 (Nov., 1960). In Russian.

Reports a study of the bending strength, impact strength and hardness of TiC—WC—Co alloys as a function of their composition, dimensions of carbide grains and the test temperature. A.Tybulewicz

6469 TIME-DEPENDENT TENSILE STRENGTH OF SOLIDS. I.H.Hall.

Nature (GB), Vol. 189, 131 (Jan. 14, 1961).

The stress at a given extension in isotactic polypropylene is plotted against log strain rate for extensions between 2 and 15%, and strain rates between 10^{-4} and 10^{3} $\sec^{-1}$ at 20° C. The linear relation between stress and log strain rate found by Hsaio (Abstr. 11983 of 1960) at strain rates of the order of 10^{-5} $\sec^{-1}$ does not hold at the higher strain rates in polypropylene. The dependence of yield stress and breaking stress on log strain rate is also shown; in neither case is the relation a linear one. R.F.S.Hearmon

6470 REPLY TO DISCUSSION "SHEAR ALONG GRAIN BOUNDARIES OF AN ALUMINIUM—10% ZINC ALLOY DEFORMED AT ROOM TEMPERATURE". N.J.Grant.

Acta metallurgica (Internat.), Vol. 8, No. 4, 275 (April, 1960).

Other experiments are quoted which, contrary to Perryman's view (Abstr. 18269 of 1960), indicate that intercrystalline cracking would be expected if the alloy was either single-phase or contained a precipitate. Since the presence of a precipitate would make grain boundary shearing more difficult, it is considered that the observation reported is significant. A.E.Kay

6471 CERTAIN CHARACTERISTICS OF THE BRITTLE FRACTURE OF METAL CRYSTALS.

E.D.Shchukin, L.A.Kochanova and V.I.Likhtman.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 5, 1064-6 (Aug. 11, 1960). In Russian.

Earlier experiments (Abstr. 6316 of 1960) on the brittle fracture of amalgamated zinc monocrystals along the basal plane had shown that there was considerable scatter in the values of fracture stress for completely identical specimens with the same inclination of the basal plane to the specimen axis. Experiments were carried out on single crystals of ~1 mm diameter with the orientation of the basal planes ranging from 20° to 70°. Metallographic examination revealed that the cleavages consisted of a series of steps with, in general, one principal step. Further examination indicated that there were basically two types of cleavage depending on the position of the principal step. Analysis of the data indicates that the scatter can be attributed to differences in the geometrical conditions under which non-homogeneous deformation takes place. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 843-6 (Jan.-Feb., 1961)]. A.E.Kay

6472 FRACTURE OF BRITTLE SOLIDS. I. DISTRIBUTION FUNCTION FOR FRAGMENT SIZE IN SINGLE FRACTURE (THEORETICAL). J.J.Gilvarry.

J. appl. Phys. (USA), Vol. 32, No. 3, 391-9 (March, 1961).

For single fracture of a brittle solid, the distribution function for fragment size is obtained on the basis of Griffith's theory of brittle strength (which postulates crack propagation when pre-existent flaws are activated by stress). Three assumptions are made: (a) Fracture proceeds by activation of flaws in the volume of the specimen, in fracture surfaces through the specimen, and in the edges produced by fracture surfaces; (b) the corresponding volume, facial, and edge flaws are distributed independently of each other when activated; and (c) activated flaws of a particular type are distributed at random, individually and collectively, in the sense of Fry. These assumptions yield directly and uniquely the probability dp(l,s,v) of formation of a fragment with total edge length, total face area, and total volume in the ranges l to l + dl, s to s + ds, and v to v + dv, respectively, as $e^{-Q}dQ$ in the general case, with Q linear in l, s, and v. The derivation yielding this Poisson form requires no assumption on the shape of a fragment or the type of fracture surface. The number dn(l,s,v) of fragments with total edge length, total face area, and total volume in the ranges l to l + dl, s to s + ds, and v to v + dv, respectively, is evaluated as the product of dp(l,s,v) by the a priori number of q of particles with these values of l,s, and v. The distribution function dn(l,s,v) meets the necessary physical requirement that the fracture process conserve volume independently of particle shape. By assuming that all fragments are geometrically similar, one can replace dp(l,s,v) and dn(l,s,v) by forms, p(x)dx and n(x)dx, respectively, which depend only on a mean linear dimension x of a fragment. The resulting expression for y, the cumulative fraction of the initial volume corresponding to fragments of dimension up to x, then yields rigorously forms of the empirical equations of Schuhmann and of Rosin and Rammler for this quantity, as limiting cases for x small. The conclusion follows that activation of edge flaws represents the dominant mode of fragmentation, in general. The moments of the distribution corresponding to the total number, the total edge length, and the total surface of the fragments are divergent; this anomaly is explained as the result of neglect of flaw depletion.

6473 FRACTURE OF BRITTLE SOLIDS. II. DISTRIBUTION FUNCTION FOR FRAGMENT SIZE IN SINGLE FRACTURE (EXPERIMENTAL). J.J.Gilvarry and B.H.Bergstrom.

J. appl. Phys. (USA), Vol. 32, No. 3, 400-10 (March, 1961).

The theoretical results of Gilvarry for the size distribution of the fragments in single fracture have been verified experimentally by fracturing spherical glass specimens under compression. The fragments were contained by a gelatin matrix to inhibit secondary fracture and thus make conditions conform as closely as possible to single fracture. Experimental values of the probability of fracture as obtained by sieve analysis show the predicted linear variation with the mean dimension x of the particles, over reasonably large intermediate ranges of the variables. It is shown that a logarithmic-normal distribution does not represent the experimental results. The overall data exhibit three local maxima in the differential probability of fracture as a function of x, whereas the theory permits only two. Agreement in the number of peaks is obtained by subtracting the contribution to the overall probability of those fragments containing original surface of the specimen, which yields the true probability considered in the theory. In this manner, reasonably complete agreement between theory and experiment for single fracture is obtained. For plural fracture (carried out without use of gelatin), two additional peaks exist in the curve of the overall differential probability versus x, as compared to the case for single fracture. The theory of Gilvarry is confirmed down to a fragment dimension of at least 1 μ by means of an electrical counting instrument, and checked by direct microscopic sizing to 5 μ. The results yield numerical values of internal flaw densities, and thus provide a tool to study the distribution of Griffith flaws existing internally in a solid.

6474 ON THE FRACTURE BEHAVIOUR OF MAGNESIUM OXIDE BI-CRYSTALS. A.R.C.Westwood.

Phil. Mag. (GB), Vol. 6, 195-200 (Feb., 1961).

Metallographic studies on compressed bi-crystals of magnesium oxide revealed cracks formed at the grain boundary by piled-up groups of edge dislocations. However, these were produced only when two slip bands, one from each grain, met at the boundary; cracks associated with a single pile-up were not observed. Crack propagation was transgranular, and by crystallographic cleavage. A mechanism for crack formation at low strains is proposed in which a source, situated on the opposite side of the grain boundary and some two to eleven microns away from a piled-up group of edge dislocations, can be activated by the stress field of this pile-up and produce dislocations which under certain conditions, may cooperate with the activating group to form a crack.

6475 THE PROPAGATION OF A BRITTLE CRACK.

K.B.Broberg.

Ark. Fys. (Sweden), Vol. 18, Paper 10, 159-92 (1960).

The propagation characteristics of a crack in a brittle, linear elastic material were investigated. In order to obtain a mathematical description, the material is supposed to be homogeneous and isotropic both as regards stress-strain relations and fracturing characteristics. It is a priori assumed that a two-dimensional crack can be propagated and that this crack propagates in one plane, only. Further, the surface energy of the material is supposed to be zero. Then the crack-tip velocity will be constant (cf. Mott, 1948), and the problem of the crack propagation can be investigated by a study of displacements and stresses in a semi-infinite solid, where the plane surface is subjected (1) to a constant pressure, acting on an infinite strip, the width of which is symmetrically increasing from zero with a constant velocity, and (2) to a pressure outside this strip such that the normal displacement of the surface outside this strip is zero. This mixed boundary value problem is treated. The stresses in the solid and the normal displacement of the surface are solved exactly. The result shows that the displacement of the surface is elliptic, just as in the corresponding static case. By studying the stresses in the vicinity of the edge of the strip and using some simple fracture criteria it can be shown that the assumption a priori regarding the existence of a two-dimensional crack propagating in one plane is justified. Further it can be concluded that the crack-tip velocity equals the velocity of surface (Rayleigh) waves. In a real material, the existence of a surface energy does not seem to have such influence on the crack propagation except for the very start. The inhomogeneity and the anisotropy of the fracturing characteristics will cause deviations from a plane propagation of the crack. This fact will reduce the mean velocity of the crack in the direction of propagation. The effects of non-brittleness or deviations from Hooke's law are not discussed.

6476 ELECTRON METALLOGRAPHIC OBSERVATIONS ON THE FORMATION OF FATIGUE CRACKS.

H.A.Bendler and W.A.Wood.

Acta metallurgica (Internat.), Vol. 8, No. 6, 402-3 (June, 1960).

Wood's optical method for examining the formation and growth of fatigue cracks (Abstr. 6462 of 1958) has been extended to electron microscopy using a replica technique. Earlier studies suggested that fatigue originated in zones which etched up on the special section taken for examination as traces of abnormally distorted slip planes. These zones then opened into fissures. It is now confirmed that the zones are actually distorted slip planes (when first observed) and not fissures. Also continuous fissures observed under the optical microscope are revealed as chains of smaller discontinuous fissures by the electron microscope. A.E.Kay

6477 EFFECT OF GRAIN SIZE ON CRACK PROPAGATION.

J.J.Gilman.

Acta metallurgica (Internat.), Vol. 8, No. 9, 665-6 (Sept., 1960).

A discussion of the various factors that determine the fracture resistance as the grain size approaches zero is given. It is concluded that the fracture-surface energy (that is the effective surface energy which includes the energy dissipated at cleavage steps by plastic flow, etc.) increases with decreasing grain size up to a maximum value and then decreases to a constant value with further decrease in the grain size. It follows that one cannot improve the fracture resistance of materials indefinitely by simpl decreasing their grain size. R.Bullou

6478 THE ORIGIN AND DEVELOPMENT OF CRACKS IN DEFORMED CRYSTALS.

L.A.Kochanova, E.D.Shchukin, V.I.Likhtman and P.A.Rebinder.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 1, 71-3 (July 1, 1960).

In Russian.

For abstract, see Abstr. 16239 of 1960. [English translation in : Soviet Physics—Doklady (USA), Vol. 5, No. 4, 750-3 (Jan.-Feb 1961)].

6479 STRESSES AT A CRACK IN AN ELASTOMER.

E.H.Andrews.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 483-98 (Feb., 1961).

A microscopical, photoelastic technique was used to investigat the distributions of stress and strain around a crack in a highly elastic material, natural rubber. The finite strains encountered in such a material give rise to a distortion of the principal-stress ma an effect which has no parallel in classical elasticity and which lea to a complex dependence of the stresses upon the external constrai The strain energy at a point is however simply related to the external constraint when the latter is expressed in terms of a store energy parameter T, which is defined. The same parameter is shown to govern the distortion of the stress field. The decay of strain energy in a direction perpendicular to the crack axis is muc more gradual when the strains are finite, but the rate of decay alon the axis in the elastomer is similar, both in form and magnitude, to that predicted by infinitesimal-strain theory.

6480 A MECHANISM FOR PRODUCING EXTRUSIONS AND INTRUSIONS DURING FATIGUE. R.Nagai.

J. Phys. Soc. Japan, Vol. 14, No. 9, 1252 (Sept., 1959).

6481 FATIGUE STRAINING OF COPPER WHISKER.

E.Eisner.

Nature (GB), Vol. 188, 1183-4 (Dec. 31, 1960).

Copper whiskers were strained by cantilever loading under static and oscillatory conditions. Plastic deformation occurred as kinking, and took place under static conditions immediately suffici load was applied, but under oscillatory loading kinking could be delayed, sometimes for more than 10^5 cycles. Fatigue fracture wa not observed in unkinked whiskers, even when the specimens were repeatedly subjected to strains of about 3%. After plastic-flow had occurred, whiskers could fracture in the yielded region under sma strains. J.Fran

6482 EFFECT OF AIR PRESSURE ON THE FATIGUE OF LEAD AND ALUMINIUM. K.U.Snowden.

Nature (GB), Vol. 189, 53-4 (Jan. 7, 1961).

The fatigue life of "super pure" annealed Al, tested at room temperature, increased steadily with increasing air pressure. Th fatigue life of 99.999% Pb, tested in the same pressure range (10^3-10^{-6} mm Hg), remained constant at high pressures, increased rapidly when the air pressure decreased from about 0.15 to 5×10^{-3} mm Hg, and was practically unaffected by a further decrease in pressure. The results obtained are discussed in relation to the effect of pressure and temperature on the rate of reaction between a gas and a metal which, in turn, affects the nature of the fatigue deformation. M.H.Slobo

6483 THE GENERATION OF POINT DEFECTS BY DEFORMATION AND FATIGUE IN ALKALI HALIDES.

R.W.Davidge, C.E.Silverstone and P.L.Pratt.

Phil. Mag. (GB) (Eighth Ser.), Vol. 4, 985-7 (Aug., 1959).

Cottrell [Institute of Metals Monograph and Report Series, No. 23, p. 1 (1957)] has suggested that cyclic loading should produc more vacancies than unidirectional loading. The authors found tha fatigue in compression of NaCl crystals does indeed lead to a greater density change than ordinary compression. In fact compressive fatigue is more effective by about an order of magnitude i producing vacancies than is simple compression. R.Bulloug

6484 MICROHARDNESS AND OTHER PROPERTIES OF MAGNESIUM COMPOUNDS WITH THE CALCIUM FLUORIDE STRUCTURE. E.R.Petty.

Nature (GB), Vol. 189, 132-3 (Jan. 14, 1961).

A linear relationship between microhardness and the latent heat of fusion has been found for the series of intermetallic com-

unds: Mg$_2$Si, Mg$_2$Sn and Mg$_2$Pb and by using these results, the
tent heat of fusion for Mg$_2$Ge was deduced by interpolation. It was
und that the microhardness of these compounds also satisfies the
oldschmidt relation (Skr. Norsk. VidenskAkad. Oslo (Norway),
26, Vol. 2 (8), 102). R.Bullough

FRICTIONAL OSCILLATIONS. See Abstr. 5320

STRUCTURE OF SOLIDS

6485 CONTRIBUTION TO THE STUDY OF THE STRUCTURE OF METALLIC URANIUM. A.Bassi and C.Corsetti.

ergia nucleare (Italy), Vol. 7, No. 9, 638-48 (Sept., 1960).

Commercially pure uranium shows two polygonization
enomena which are a consequence of two allotropic transformations
$\to \beta$ and $\beta \to \alpha$. In the present paper, the results of the research
rried out and the authors' hypotheses on the nature of the subgrain
undaries are reported. The variations which one observes in the
b-structure brought about by the phase transformations under load
d by the thermal treatments are also described.

6486 AN INVESTIGATION OF THE CUBIC—HEXAGONAL TRANSITION IN BARIUM TITANATE.

.M.Glaister and H.F.Kay.
roc. Phys. Soc. (GB), Vol. 76, Pt 5, 763-71 (Nov., 1960).

Normal perovskite-type barium titanate may be converted to
e hexagonal polymorph by firing in a hydrogen atmosphere at
330° C, 130° lower than that previously reported for firing in air.
ith suitable additives such as MnCO$_3$ the conversion began at
mperatures as low as 1100° C. Conversion was inhibited by a
umber of impurities, especially Si, Fe and Sr, such as were pre-
ent in barium titanate of commercial quality. The effect of atmo-
pheres of hydrogen and oxygen on the rate of reconversion to the
ubic polymorph was also studied. In hydrogen this reached a peak
ate at about 1200° C, while in oxygen it rose continuously. All the
henomena associated with the transition appeared to be compatible
ith a proposed hypothesis about the dependence of free energy on
acancy concentration. The hexagonal polymorph had a permittivity
f about 440 and a temperature coefficient of $+0.0028\ (\mathrm{deg\ C})^{-1}$.

6487 SOLUBILITY OF EXCESS FERRIC OXIDE IN NiZn FERRITES.

.V.Latsh, N.G.Minaev, B.Kh.Somin and N.É.Stepina.
iz. tverdogo Tela (USSR), Vol. 2, No. 9, 2191-8 (Sept., 1960).
Russian.

For abstract, see Abstr. 21232 of 1960. [English translation in:
oviet Physics—Soviet State (USA), Vol. 2, No. 9, 1956-62
March, 1961)].

CRYSTALLOGRAPHY

6488 INTERNATIONAL UNION OF CRYSTALLOGRAPHY: FIFTH GENERAL ASSEMBLY, INTERNATIONAL ONGRESS AND SYMPOSIA.

cta cryst. (Internat.), Vol. 13, Pt 12, 965-1153 (Dec., 1960).

Held in Cambridge (England) from 15 to 24 August, 1960. Ab-
tracts of the papers presented are given, grouped in the following
ections: General lectures; Apparatus for diffraction measure-
ents; Techniques and methods for diffraction measurements;
ecent progress in structure determination; Minerals (including
lay minerals); Metals and alloys; Inorganic structures; Organic
ructures; Proteins and related compounds; Fibrous structures;
rder—disorder phenomena; Deformations and imperfections;
iquids, liquid crystals, amorphous materials, glasses; Phase trans-
rmation, martensitic transitions, ferroelectrics, λ-point tran-
tions; Crystal growth, morphology, twinning; Symmetry, including
tensions of space-group theory; Neutron diffraction; Electron
ffraction; Physical techniques (other than diffraction); Crystal
ta; Thermal motion in crystals and molecules; Lattice defects
d the mechanical properties of solids; Miscellaneous.

6489 THE STRUCTURE OF CRYSTAL SURFACES. N.Cabrera.

isc. Faraday Soc. (GB), No. 28, 16-22 (1959).

"Crystal imperfections" discussion (see Abstr. 2386 of 1961).
summary is given of the important, and well-established, ideas on
e structure of surfaces. In addition, several detailed points are
chosen for further consideration. A careful distinction is first made between singular, vicinal and non-singular surfaces and the full implications of this distinction are discussed. Then follows a discussion on the structure of singular (and vicinal) surfaces with particular reference to the concentrations of surface point defects at high temperatures, and their mobility and lifetime on the surface. Finally a detailed, classical, discussion of the condensation coefficient is given. R.Bullough

6490 ANISOTROPIC TENSORS. Yu.I.Sirotin.

Dokl. Akad. Nauk SSSR, Vol. 133, No. 2, 321-4 (July 11, 1960). In Russian.

For abstract, see Abstr. 16247 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 774-7 (Jan.-Feb., 1961)].

6491 A NEW INTERPRETATION OF THE SUBSTRUCTURE OF ELECTROPOLISHED ALUMINIUM SURFACES.

M.G.Holló.
Acta metallurgica (Internat.), Vol. 8, No. 4, 265-8 (April, 1960).

Direct-transmission electron micrographs of thin oxide films, formed by electropolishing in a phosphoric acid—butyl alcohol bath, showed characteristic patterns of hexagonal network. Size—voltage relations of cell size and pore diameter gave parabolic type curves and a new explanation of the hexagonal structure of such oxide films is given. R.Bullough

6492 DISLOCATION ETCH PITS ON BISMUTH TELLURIDE CRYSTALS. I.Teramoto and S.Takayanagi.

J. appl. Phys. (USA), Vol. 32, No. 1, 119-20 (Jan., 1961).

On freshly cleaved surfaces triangular and hexagonal etch pits are obtained believed to be associated with dislocation patterns only (because etch patterns on the two surfaces were mirror images of each other). Recipes for etching solutions are given, and two micrograms of surfaces. Pit densities vary from 10^5 to 10^8/cm^2, and are reduced on prolonged annealing above 400° C. F.Ansbacher

6493 CATHODIC ETCHING IN A PENNING COLD CATHODE DISCHARGE. P.T.Stroud.

Vacuum (GB), Vol. 9, No. 5-6, 269-73 (Nov., 1959 - Jan., 1960).

An apparatus for cathodic etching using a Penning cold cathode discharge is described. One of the twin cathodes is the specimen to be etched whilst the other is made of aluminium. The cathodes are water cooled so that metals of either low melting point or low sputtering rate will not overheat during the cathodic etching. The Penning system is used because the glow discharge can be maintained at a sufficiently low pressure ($\leq 1\mu$ Hg) for most of the sputtered atoms to escape from the specimen surface and not be returned by collision with gas molecules. The higher sputtering rate attained at low pressure permits etch patterns to be obtained speedily. Several metals viz. phosphor bronze, copper, pure iron, mild steel, bismuth, cadmium and Telcoseal 5 (an alloy consisting of 25 per cent chromium in iron with additions of manganese and silicon) were cathodically etched satisfactorily and photomicrographs of some of the etched surfaces prepared. Generally the cathodically etched surfaces were similar to those obtained by chemical etching, but only cathodic etching truly exposed the crystalline structure of Telcoseal 5.

6494 THE GROWTH ORIENTATION OF FERRITE SINGLE CRYSTALS. G.Elbinger and U.Rösler.

Ann. Phys. (Germany), Vol. 7, No. 1-2, 111-12 (1961). In German.

Single crystals of nickel and magnesium ferrites were grown at unusually slow rates (0.5 mm/hr) by the Verneuil method. These crystals showed no preferred growth directions. Growth in the $\langle 110\rangle$ and $\langle 111\rangle$ directions was not observed in nickel ferrite; in magnesium ferrite the forbidden directions were closer to the $\langle 110\rangle$ direction. The spread in observed growth directions was greater in magnesium ferrite than in nickel ferrite. J.Holt

6495 APPLICATION OF AN INTERFEROMETRIC METHOD IN POLARIZED WHITE LIGHT TO THE STUDY OF CRYSTAL GROWTH. M.Follenius.

Bull. Soc. Franc.Mineral. Crist., Vol. 82, No. 10-12, 343-60 (Oct.-Dec., 1959). In French.

Describes a method based on interference measurements of concentration gradient around the crystal. Results of measurements are given for KBr, KCl, KI, NaClO$_3$, and several other salts. A.R.Stokes

6496 VELOCITY OF LAYER-SPIRAL GROWTH OF CRYSTALS FROM SOLUTION AND FROM THE MELT. A.A.Chernov.
Dokl. Akad. Nauk SSSR, Vol. 133, No. 6, 1323-6 (Aug. 21, 1960). In Russian.

For abstract, see Abstr. 21158 of 1960. [English translation in: Soviet Physics—Doklady (USA), Vol. 5, No. 4, 654-7 (Jan.-Feb., 1961)].

6497 GROWTH FROM THE VAPOR OF LARGE SINGLE CRYSTALS OF LEAD SELENIDE OF CONTROLLED COMPOSITION. A.C.Prior.
J. Electrochem. Soc. (USA), Vol. 108, No. 1, 82-7 (Jan., 1961).

Lead selenide crystals were grown by sublimation using a technique in which almost the whole charge of a few grams is frequently converted into only one single crystal. A substantial measure of control of the Pb:Se ratio of the resulting crystals is achieved by independent control of the partial vapour pressure of selenium during growth, giving carrier concentrations more than an order lower than has been achieved in crystals grown from the melt.

6498 SYNTHESIS OF THE CUBIC FORM OF BORON NITRIDE. R.H.Wentorf, Jr.
J. chem. Phys. (USA), Vol. 34, No. 3, 809-12 (March, 1961).

A study of the formation of cubic boron nitride shows that the alkali and alkaline earth metals and their nitrides are effective catalysts for converting hexagonal boron nitride into cubic. The pressure and temperature required varies with the catalyst, and a minimum of about 45 000 atm and 1500° C was found to be optimum.

6499 GROWTH OF YTTRIUM IRON GARNET SINGLE CRYSTALS BY THE FLOATING ZONE TECHNIQUE.
L.L.Abernethy, T.H.Ramsey, Jr and J.W.Ross.
J. appl. Phys. (USA), Suupl. to Vol. 32, No. 3, 376S-377S (March, 1961).

A $MoSi_2$ susceptor was used to melt and move an iron-rich zone through polycrystalline YIG bars. Crystals 0.25 in. diam., or larger, with dielectric constant about 10 and dissipation 0.002, were obtained using the highest stable-zone temperature, a zoning rate of 0.1 in./hr, and an O_2 pressure of 100 lb/in^2. Silicon contamination, crystalline imperfections, or nonequilibrium phases broadened line-width, but highly polished test spheres yielded ΔH values of 1-2 Oe.

6500 THE SYNTHESIS AND CRYSTALLOGRAPHY OF STRUCTURALLY PURE CUBIC AND HEXAGONAL SINGLE CRYSTALS OF ZnS. H.Samelson and V.A.Brophy.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 150-4 (Feb., 1961).

A sealed-tube vapour-phase method for growing zinc sulphide single crystals of either a structurally pure hexagonal or structurally pure cubic form is described. In the former case, the crystals are of a high degree of chemical purity, but to effect the latter, KCl is employed as an additive and this results in crystals of somewhat uncertain chemical purity. The nature of the faulting commonly found in zinc sulphide is discussed, and the effect of this on the X-ray diagrams is described. The morphology of the structurally pure crystals is described in some detail.

RESISTIVITY CALCULATIONS FOR SEMICONDUCTOR CRYSTALS GROWN BY THE CZOCHRALSKI TECHNIQUE. See Abstr. 6145

6501 GROWTH OF WHISKERS BY CHEMICAL REACTIONS. C.R.Morelock and G.W.Sears.
J. chem. Phys. (USA), Vol. 34, No. 3, 1008-9 (March, 1961).

The general conditions for the growth of whiskers by vapour deposition is considered. If several reactions are available to grow a given crystal phase, that reaction with the lowest entropy of reaction will allow the growth of near-perfect crystals, at the largest temperature difference between source crystals and growing crystals.

6502 OXIDATION OF COPPER BETWEEN 250° AND 450° C AND THE GROWTH OF CuO "WHISKERS".
E.A.Gulbransen, T.P.Copan and K.F.Andrew.
J. Electrochem. Soc. (USA), Vol. 108, No. 2, 119-23 (Feb., 1961).

Thin oxide whiskers have been found to grow on copper by a number of investigators. The relation of these growths to the mechanism of oxidation and to changes in the kinetics of oxidation remains to be established. To answer these questions a study was made of the oxidation of copper using the vacuum microbalance method to determine the kinetics of reaction, X-ray and electron diffraction methods for study of the oxide crystal structures, and a high resolution electron microscope to determine the size and surface density of the oxide whiskers. The results show that the oxidation of copper follows the cubic rate law between 250° and 450° C. Small embryoni whiskers are formed at 250° C and 6 hr of reaction. A surface density of 10^8 cm^{-2} of long thin oxide whiskers was found at 450° C after 6 hr of oxidation. Less than 1% of the oxygen reacting with the metal at 450° C resulted in the growth of oxide whiskers, althou of great interest as a natural phenomena, had no appreciable effect on the kinetics of the oxidation process.

6503 SURFACE STUDIES OF DENDRITIC GROWTH OF GERMANIUM CRYSTALS.
V.G.Bhide and V.M.Chandratreya.
J. sci. industr. Res. (India), Vol. 19B, No. 12, 488-91 (Dec., 1960).

Optical and interferometric studies of the dendrites of germanium grown from undercooled melt have shown clearly the existence of a twin plane in the centre which extends all along the dendrite, a postulated by Bennett and Longini (Abstr. 1891 of 1960).

6504 VISIBLE TWIST ON SODIUM CHLORIDE WHISKERS. B.Jeszenszky and E.Hartmann.
Nature (GB), Vol. 189, 213 (Jan. 21, 1961).

NaCl whiskers were grown 150 mm long and 1-30 μ thick. Th amount of twist of the whiskers was deduced from the spacing of reflected light spots, giving a Burgers vector of 60-240A for a screw dislocation causing the twist. The whiskers could not be permanently straightened by untwisting. J.Frank

6505 WHISKER GROWTH FROM QUARTZ. R.J.Jacoodine and R.K.Kline.
Nature (GB), Vol. 189, 298 (Jan. 28, 1961).

Whiskers of various lengths resulted from fused quartz held a 1425°C for 24 hours. The phenomenon is discussed and some details are given. H.E.Schmi

EPITAXIAL GROWTH AND MAGNETIC PROPERTIES OF SIN CRYSTAL FILMS OF IRON, NICKEL, AND PERMALLOY.
See Abstr. 6318

CRYSTAL CHEMISTRY OF SEMICONDUCTORS.
See Abstr. 6139

CRYSTAL LATTICE STRUCTURES

CRYSTALLOGRAPHY CONFERENCE, CAMBRIDGE 1960.
See Abstr. 6488

6506 TOWARDS A THEORY OF THE CRYSTALLOGRAPHIC POINT GROUPS. H.V.McIntosh.
J. molecular Spectrosc. (USA), Vol. 5, No. 4, 269-83 (Oct., 1960).

The theorems to be expected in a comprehensive theory of bot the double and single crystallographic point groups are summarize Based upon their decomposition as semidirect products, it is show how the theory may yield a nomenclature for the groups and their representations, and a factored form for the projection operators belonging to the rows of the irreducible representations. This factorization is used to discuss the reduction of spherical harmonics according to their point group symmetry, as well as to discuss normal coordinate analyses, the construction of symmetric Hamiltonians, and the derivation of selection rules. The selection rules follow from the reduction of Kronecker product representations. T equivalence of complex conjugate representations and the construction of unitary representation is discussed. The entire analysis is predicated upon a certain canonical form for the representation of a semidirect product, which is described.

6507 CAYLEY SQUARES FOR THE CUBIC GROUPS. N.V.Belov and T.N.Tarkhova.
Kristallografiya (USSR), Vol. 5, No. 1, 129-34 (Jan.-Feb., 1960). I Russian.

The Cayley squares for two cubic point groups, 0 = 432 and $T_h = m^3$, are tabulated. The first 12 × 12 cells of the 0 = 432 table form the square for T = 23. Group $T_d = \bar{4}3m$ is isomorphous with 0 = 432 so its square is found by putting $\bar{4}$ for the coordinate 4 axes and 2 for the diagonal 2 axes in the square for 0. [English translation in: Soviet Physics—Crystallography (USA), Vol. 5, No. 1, 119-24 (July-Aug., 1960)]. J.Iba

6508 GROUP REPRESENTATIONS AND SOLID STATE PHYSICS. W.Opechowski.
Trans. Roy. Soc. Canada Sect. III, Vol. 54, 9-18 (June, 1960).

Elementary exposition of the nature of space groups and their role in the theory of solids. J.Hawgoo

6509 · DESIGN FOR A THREE-CIRCLE X-RAY GONIOMETER.
R.W.H.Small and S.Travers.

sci. Instrum. (GB), Vol. 38, No. 5, 205-6 (May, 1961).

Using the scheme first described by Furnas and Harker, for the ollection of three-dimensional intensity data from a single crystal which the motion of the counter tube is restricted to a horizontal ane, a comparatively simple instrument has been designed. Parti-ular attention has been given to the design of simple bearings which e free from backlash and wear, and which permit the recording of ffracted beams up to an angle 2θ of 165°. The instrument has rovision for scanning and recording integrated intensities over an c of 4°. Some details of performance are given.

6510 X-RAY DIFFRACTION DATA FROM SINGLE CRYSTALS AT 20°K.
J.D.Forrester.

sci. Instrum. (GB), Vol. 38, No. 4, 153-6 (April, 1961).

A liquefier cryostat is used to produce the liquid hydrogen nd the crystal is cooled in situ to liquid-hydrogen temperature. his method introduces problems involving crystal cooling, crystal ounting, the rotation of the crystal and the provision of X-ray ransparent windows in the cryostat walls. These are discussed, gether with some preliminary results obtained with the pparatus.

6511 HOW TO OBTAIN THE INTRINSIC DIFFRACTION PROFILES OF X-RAYS BY REFLECTION AND BY RANSMISSION.
A.Authier

.R. Acad. Sci. (France), Vol. 251, No. 22, 2502-4 (Nov. 28, 1960). French.

An X-ray beam was reflected successively by two highly erfect silicon crystals and by the crystal under investigation. The roadening due to wavelength spread and lack of parallelism of the eam was thus made small compared with intrinsic broadening in e specimen. A.R.Stokes

6512 DIFFRACTION OF ELECTRONS THAT HAVE TRAVERSED A FINITE THICKNESS OF MATERIAL.

.Brú, R.Márquez and F.Ramos.

n. Real Soc. Espan. Fis. Quim. (Spain), Vol. 55A, No. 9-10, 229-32 ept.-Oct., 1959). In Spanish.

Electron-diffraction photographs are reproduced to show the fect of passing the incident beam through a gold layer 1 μ thick. e diffraction pattern is changed very little. A.R.Stokes

6513 AN EFFECT OBSERVED ON PULVERIZATION OF CRYSTALLINE BORON.

.P.Tsomaya and R.R.Shvangiradze.

iz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 791-2 Nov., 1960). In Russian.

Reports that X-ray and electron diffraction patterns disappeared n grinding small boron crystals to a very fine powder. This ndicated a loss of crystal structure. No such effect was found in ilicon, germanium and boron carbide. A.Tybulewicz

6514 STRUCTURES OF SULFUR—SELENIUM MIXTURES.
Y.M.De Haan and M.P.Visser.

hysica (Netherlands), Vol. 26, No. 2, 127-32 (Feb., 1960).

Most mixed structures of sulphur and selenium are built up rom 8-atomic ring molecules in essentially the same way as the ure elements. These ring modifications are all soluble in CS_2. At ll mixing ratios chain modifications may also occur. They are of e same kind as found with the pure elements, but the great trength of extended pure sulphur fibres is not retained in the mixed tructures. One new structure type (C), and possibly a second one)), were found, but not fully analysed. The question whether mixed onds S—Se occur as readily in rings or chains as pure S—S and ure Se—Se bonds (each in their own kind of molecules) remains nsettled.

6515 LATTICE DIMENSIONS OF NbC AS A FUNCTION OF STOICHIOMETRY.

P.Kempter, E.K.Storms and R.J.Fries.

chem. Phys. (USA), Vol. 33, No. 6, 1873-4 (Dec., 1960).

Precision lattice-constant measurements of previous workers, torms and Krikorian, J. phys. Chem., Vol. 63, 1747 (1959); Abstr. 349 of 1960] on the Nb/C system were combined with additional gh C/Nb ratio determinations to improve the lattice constant versus 'Nb molar ratio curve. Measurements were made at 25° C using a .00 cm symmetrical-back-reflection focusing camera with Fe-tered Co-radiation, and an 11.459 cm Debye—Scherrer camera with -filtered Cu-radiation. The C/Nb range covered by 41 specimens s 0.700 to 0.996. Corrections were applied for refraction errors and systematic errors in $\Delta a/a$. A least squares fit of (a - 4.4) versus C/Nb using weighted points gave the equation:

$$a = 4.09847 + 0.71820\ C/Nb - 0.34570\ (C/Nb)^2.$$

When C/Nb = 1, a = $4.4710 \pm 0.0001_5$ A. The theoretical density versus C/Nb curve was also plotted; it has a minimum of 7.716 g cm^{-3} at $NbC_{0.785}$, and a maximum of 7.796 g cm^{-3} at $NbC_{1.000}$. Over this molar range the lattice is NaCl type. The density of hexagonal Nb_2C is about 7.95 g cm^{-3} and of b.c.c. Nb is 8.53 g cm^{-3}. R.V.Coates

6516 THE POLYMORPHISM OF THALLIUM AND OTHER HALIDES AT LOW TEMPERATURES.

M.Blackman and I.H.Khan.

Proc. Phys. Soc. (GB), Vol. 77, Pt 2, 471-5 (Feb., 1961).

Thin layers of caesium, rubidium and thallium halides were evaporated onto amorphous bases at low temperatures, and examined by electron diffraction. All the caesium halides examined, as well as thallium chloride and thallium bromide, showed both the rocksalt structure as well as the normal caesium chloride structure. In general the abnormal structure gave the weaker pattern which decreased in intensity as the layer was heated and disappeared before room temperature was reached. Thallium iodide showed a caesium chloride structure at low temperatures changing to the normal orthorhombic form only in the neighbourhood of room temperature. The rubidium salts showed a rather persistent broad ring pattern at low temperatures in addition to the normal rocksalt rings. The diffuse ring pattern is consistent with a caesium chloride structure for the rubidium halides.

6517 X-RAY INVESTIGATION OF THE FORMATION OF REFRACTORY ALUMINA.

P.Smith, M.A.Berger and F.G.Ruimonte.

An. Real. Soc. Espan. Fis. Quim. (Spain), Vol. 55A, No. 7-8, 195-7 (July-Aug., 1959). In Spanish.

Alumina was prepared by two chemical methods and heat-treated at 1100°C for 4 hr:: in both cases the powder photograph showed α-Al_2O_3. At lower temperatures some γ-Al_2O_3 was also formed. A.R.Stokes

6518 LOW-TEMPERATURE FORMS OF ICE AS STUDIED BY X-RAY DIFFRACTION.
L.G.Dowell and A.P.Rinfret.

Nature (GB), Vol. 188, 1144-8 (Dec. 31, 1960).

A determination was made of the temperature ranges in which the various phases exist and the rates of transformation from one phase to another. Vitreous ice is only produced by condensing vapour on a surface below −160° C. Above this temperature it changes to cubic ice. Above −130° C this changes to hexagonal ice I. The low-temperature X-ray equipment is described in detail. The diamond cubic face is measured and analysed. The structure of the vitreous phase is discussed and two alternative theories are proposed. It is concluded that in vitreous ice, domains exist with a tendency towards the same layer structure as in the crystalline phases, though with a random distribution of molecules within the layers. S.Tolansky

CRYSTALLOGRAPHIC PROPERTIES OF Ag_2Se. See Abstr. 6186

6519 STRUCTURE OF NICKEL CHROMITE.
E.Prince.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 68S-69S (March, 1961).

Nickel chromite is a normal spinel whose structure has a tetragonal distortion below about 310°K. The structure parameters were determined by neutron diffraction at 77°K, at which temperature the c/a ratio of a face-centred unit cell is 1.04. The space group is $I4_1/amd$ with four Ni ions in positions 4(a), eight Cr ions in positions 8(d), and 16 O ions in positions 16(h) with y = 0.239 and z = 0.392. The two independent Cr—O distances are 1.98 A and 1.99 A, indicating that the octahedron is not greatly distorted. The tetrahedron around the nickel is elongated by nearly 14% parallel to the c axis. Below a Curie temperature of about 65°K, nickel chromite has a small ferromagnetic moment. The neutron diffraction pattern at 4.2°K shows extra peaks which can be indexed on the basis of a primitive cell having the same dimensions as the body-centred chemical cell. The intensities of these peaks cannot be accounted for by any simple model for the magnetic structure. In fact, a systematic search of possible structures belonging to magnetic space groups with symmetries as low as classes m'm'2 and mm'2' has failed to turn up any structure which is consistent with the diffraction data.

6520 CATION DISTRIBUTIONS IN MAGNESIUM—NICKEL FERRITES. C.J.Kriessman and S.E.Harrison.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 392S-393S (March, 1961).

The dependence of the nonthermal part of the internal energy (u_1) of mixed MgNi ferrites, $\mathrm{Mg_yNi_{1-y}Fe_2O_4}$, on the cation distribution was studied. The cation distribution, which is characterized by the parameters η (the fraction of Mg ions on tetrahedral sites) and ξ (the fraction of Ni ions on tetrahedral sites), is determined from measurements of the saturation magnetization of samples quenched from temperatures between 1400° and 400° C. As in the case of MgMn ferrites it is found that

$$u_1 = u_0 + R(\theta_0 - \tfrac{1}{2}\theta_1\eta^2).$$

The parameters θ_0 and θ_1 are related to the energies necessary to transport Mg ions from octahedral (B) to tetrahedral (A) sites. The Madelung energy portion of θ_0 predicts a linear dependence of θ_0 on y and this is observed experimentally. It is also demonstrated that θ_0 is increased considerably by the substitution of Ni ions for Mn ions in the spinel lattice as dictated by the Madelung energy. The dependence of θ_1 on y can also be qualitatively explained. It is shown that the magnetic moment data considered as a function of composition can give useful information about the degree of inversion in the spinel lattice despite the two degrees of inversional freedom (ξ and η). The variation of the maximum attainable value of η with composition depends on ξ and the magnetic moment of the Ni ion. Values of ξ and the Ni ionic magnetic moment compatible with the observed data are discussed.

6521 ANALYSER FILTER FOR AN ELECTRON-OPTICAL SYSTEM AND ITS APPLICATION TO ELECTRON DIFFRACTION. II. KIKUCHI LINES AND THE SPOTS OF ANTHRACENE. F.Catalina.

Ann. Real. Soc. Espan. Fis. Quim. (Spain), Vol. 55A, No. 7-8, 207-12 (July-Aug., 1959). In Spanish.

For previous work, see Abstr. 8221 of 1959. An energy filter (Abstr. 6081 of 1953), of 3 eV resolving power produced no detectable change in the Kikuchi lines of mica; it is concluded that the electrons have lost a negligible amount of energy to the crystal lattice. The filter method was also applied to the diffuse spots of anthracene.

A.R.Stokes

ALLOYS . METALLURGY

6522 INTERFACE ENERGY STUDIES OF SOME COPPER-BASE ALLOYS CONTAINING AN INSOLUBLE LIQUID PHASE. I. A.A.Krishnan and V.Ramachandran.

Indian Institute of Science Golden Jubilee Research Volume (see Abstr. 2678 of 1961) p. 250-7.

The significance of interphase and intercrystalline boundary energies in determining the microstructures of alloys is explained. The influence of various alloying additions to bismuth-embrittled copper on the dihedral angle of bismuth-rich phase versus α/α solid solution is studied. The possibility of control of liquid metal corrosion and intergranular failure of alloys due to the presence of a liquid or a brittle phase is stressed.

6523 METALLURGY AND MAGNETIC PROPERTIES OF AN Fe--Co--V ALLOY. C.W.Chen.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 348S-355S (March, 1961).

A comprehensive study of the 49% Fe—49%Co--2% V alloy has revealed many new aspects of the metallography of the alloy and led to a better understanding of its mechanical and magnetic properties. Results of the study necessitate revision of previous reports on the metallography by Greiner and Ellis and Köster and Schmidt. In addition to the well-known phase transformation of γ (f.c.c.) to α (b.c.c.) and the ordering of the α phase, a martensitic transformation was established. The rapid kinetics of the $\gamma \rightarrow \alpha$ transformation can be suppressed by drastic quenching in favour of a diffusionless transformation. Martensite is a metastable b.c.c. structure which decomposes slowly into ordered α at intermediate temperatures. Ordering of the α phase is accompanied by pronounced grain refining. X-ray diffraction studies, elevated temperature measurements of saturation, and metallographic examination have not, however, confirmed the decomposition of the ordered α phase suggested by Greiner and Ellis. The problem of brittleness was broadly investigated. Cleavage fracture is a major cause of brittleness. Other causes include the gaseous (hydrogen and oxygen) embrittlement at grain boundaries and the cracking at the incoherent interface between the α phase amd martensite. Unless specially treated, all b.c.c. constituents, including disordered α, are inherently susceptible to cleavage fracture. The effect of order on the susceptibility to cleavage fracture and the multiple functions of quenching in the attainment of ductility have been elucidated in terms of current theories of cleavage fracture and lattice imperfections. The main purpose of quenching is to produce a martensitic structure. Only when a ductile matrix has been prepared, can ordering exert an adverse effect on the ductility of the alloy. Measurements of saturation magnetic moment at elevated temperatures disclose a 2% increase caused by ordering. Room-temperature magnetization curv are compared for different microstructures. The electronic configuration outside the argon core of vanadium atoms is discussed in relation to the composition variation of the average magnetic mome of Fe—Co—V alloys.

6524 STATIC DISTORTIONS AND WEAKENING OF LINE INTENSITIES IN X-RAY OR NEUTRON DIFFRACTION PATTERNS OF SOLID SOLUTIONS WITH FACE-CENTRED CUBIC LATTICES. M.A.Krivoglaz.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 2, 169-82 (Aug. 1960). In Russian.

Displacements of atoms at various distances from an impurity and root-mean-square displacements in substitutional and interstit solid solutions with face-centred cubic lattices are calculated with allowance for the crystal structure and related to changes in X-ray or neutron diffraction patterns.

A.Tybulewic

6525 STRUCTURE OF ALNICO V. R.B.Campbell and C.A.Julien.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 192S-194S (March, 1961).

The microstructure and crystal structure characteristics of Alnico V in various conditions of heat treatment were determined by electron transmission microscopy and by electron and X-ray diffraction. The a_0 values of the different cubic phases have been determined from the electron diffraction data by using an MgO smoke film as an internal standard. In the water-quenched condition this material is a single-phase b.c.c., with $a_0 = 2.84$ A. Trans mission electron micrographs of the material in the magnetic-fie cooled condition show a structure appearing to be comprised of a matrix phase and oriented precipitate particles whose size is dependent on the cooling rate. Corresponding transmission diffraction patterns of such micrographed regions indicate that the matrix and precipitate are both part of the same crystallographic entity having the same crystal symmetry and, within experimental error, the same lattice parameter as the water-quenched materia Diffraction patterns of slowly cooled specimens indicate the presence of small quantities of another constituent, b.c.c., $a_0 = 2.62$ A. In the fully heat-treated (i.e. field,cooled plus coercive-aged) condition, the same microstructural appearance an lattice parameters, within experimental error, prevail, although magnetic tests show that a marked increase in anisotropy has occurred. Diffraction patterns from regions consisting exclusivel of (deliberately induced) "gamma phase" indicate a randomly oriented, fine grained (5-6 grains/μ^2) b.c.c. structure, $a_0 = 2.84$ A.

6526 CRYSTAL LATTICE INVESTIGATION OF THE PERMANENT MAGNET PRECIPITATE IN VARIOUS ALNICO MATERIALS. K.J.Kronenberg.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 196S-198S (March, 1961).

Transmission electron diffraction was applied to study the crystal lattices of various Alnico materials. The method seems to be accurate enough to determine quantitatively the differences in lattice parameters of different Alnico materials in the as-cast stat During the technical heat treatment a phase precipitates which has a lattice parameter of 2.88 ± 0.03 A. Within the limits of error this parameter was found to be uniform for all investigated Alnico alloys in spite of their different original composition, even includin Alnico VIII, which contains 34% Co, 7.5% Al, 14.4% Ni, 4.5% Cu, 5.0 Ti, balance Fe. The different magnetic properties of different Alnico magnets are correlated to the mosaic structure and the degree of ordering achieved by the precipitated phase. These factors vary considerably for the different Alnico materials as electron diffraction reveals. In Alnico V, particularly in the grade with columnar crystal growth (energy product above 7 × 10^6 gauss oersted), the precipitate appears to develop into a network extending continuously throughout the magnet body displaying single crystal order.

6527 . CUBE TEXTURE IN ULTRATHIN MOLYBDENUM PERMALLOY TAPE.

P.K.Koh.

appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 358S-359S
larch, 1961).

With identical annealing heat treatment, the role of the major nealed texture component seems to depend primarily upon the egree of cold reduction. Cube texture was evident when all three icknesses of tape, $\frac{1}{2}$ mil, $\frac{1}{4}$ mil, and $\frac{1}{8}$ mil, were annealed at 760° C. n raising the annealing temperature to 927° C, there was no trace cube texture in tape which was cold reduced 96.9% before annealg. But cube texture still remained as the strongest annealing texre component in tapes similarly treated at 927° C but cold reduced ly 93.8% and 87.5% respectively, before annealing. The present esults agree to some extent, although not entirely, with previous vestigators on the transitional nature of cube texture in materials milar to, but not the same as, the present tape. The switching cocicient S_W increases with increasing cube pole concentration in the rder of increasing thickness of tapes annealed at 760° and 927° C. herefore, $\frac{1}{2}$-mil tape with the highest value of S_W would have the ngest switching time in μsec under a constant applied field. The quareness ratio of the hysteresis loop, B_r/B_m, at the applied field $\frac{1}{2}$ Oe decreases with the increasing cube pole concentration in the rder of increasing thickness of tapes annealed at 760° and 927° C. o correlation could be found between cube pole concentration in nealed tapes and observed coercive force.

6528 SOME STRUCTURAL RESULTS ON METALLIC PHASES. VI.

.Schubert, T.R.Anantharaman, H.O.K.Ata, H.G.Meissner,
.Potzschke, W.Rossteutscher and E.Stolz.

aturwissenschaften (Germany), Vol. 47, No. 22, 512 (1960).

For Pt V, see Abstr. 5099 of 1961. Unit cell dimensions and ructure types are given for the following alloys of transition metals d B-group elements: Zr_2Al, Zr_2Al_3, Cr_3Ga, $CrGa_3$, Mn_3Ga, MnGa, nGa_3, $Fe_{55}Ga_{45}$, Hf_3Al_2, Hf_4Al_3, Zr_2Ga_3, Hf_2Al_3, $HfAl_2$, $HfAl_3$, $HfAl_{3+}$, Au_2, $HfAu_3$, $HfAu_4$, $HfAu_5$, Nb_3Au_2, $Nb_{11}Au_9$, $NbAu_2$, Zr_4Sn, Co_5Ge_7.

J.Thewlis

THE EFFECT OF SULPHUR ON THE SURFACE PROPERTIES ND STRUCTURE OF NICKEL—CARBON ALLOYS. See ostr. 5265

CORRELATION BETWEEN ELECTRICAL RESISTIVITY AND NTERACTIONS BETWEEN THE COMPONENTS OF LIQUID IETALLIC SYSTEMS. TERNARY SYSTEM Zn-Cd-Sb. ee Abstr. 5284

6529 THERMODYNAMICAL INVESTIGATIONS ON METALLIC SYSTEMS. XII. DETERMINATION OF THE MISIBILITY GAP BY CALCULATION, USING THE THERMOYNAMICAL FUNCTIONS, FOR THE TERNARY SYSTEM Zn-Sn-Pb.

[.Fiorani and L.Oleari.

icerca sci. (Italy), Vol. 29, No. 11, 2349-58 (Nov., 1959). In alian.

For Pt XI,see Abstr. 142 of 1961. An application to the ternary ystem Zn-Sn-Pb, with minor modifications, of the method reviously applied to the system Zn—Sn—Bi.

L.Pincherle

6530 THE MARTENSITIC TRANSFORMATION OF ALUMINIUM BRONZES OF HYPOEUTECTOID)MPOSITION.

J.M.Sistiaga and J.Hernáez.

ı. Real. Soc. Espan. Fis. Quim. (Spain), Vol. 55A, No. 7-8
ıly-Aug., 1959). In Spanish.

Cooling curves, electrical resistance measurements, and ray powder photographs were used to find the temperature at ıich the transformation started, for a series of compositions.

A.R.Stokes

6531 THE EFFECT OF HYDROSTATIC PRESSURE ON THE POTENCY OF MARTENSITIC EMBRYOS.

Kaufman, A.Leyenaar and J.S.Harvey.

cta metallurgica (Internat.), Vol. 8, No. 4, 270-2 (April, 1960).

The effect of hydrostatic pressure on the f.c.c. ⇌ b.c.c. reaction ıs measured on a Fe—Ni 10% alloy by resistance measurements at essures up to 60 katm. It was found that M_s was depressed by out 5° C/katm and A_s by 2° C/katm. Thermodynamic reasoning is ed to predict that the application of hydrostatic pressure during e austenizing process should produce a marked change in the tency or size of martensitic embryos. Further it is deduced that e application of hydrostatic pressure at austenizing temperatures ove the "freezing-in" temperature T_f for the embryos, followed by enching under pressure, should result in the "freezing-in" of smaller embryos. This should also lower M_s even at normal pressures provided that the hydrostatic pressure is removed below T_f. Pressure-quenching experiments and annealing studies were carried out on a Fe—Ni 32.4 at.% alloy to test these predictions. They support the idea that martensitic nucleation is controlled by the potency of embryos having the martensitic structure and existing at temperatures where the bulk chemical free energy of the austenite is lower.

A.E.Kay

6532 A RELATIONSHIP BETWEEN THE DEGREE OF ORDERING IN THE α-PHASE AND THE α—γ TRANSFORMATION IN Fe—Co—V ALLOYS.

I.L Aptekar' and V.I.Gorbunov.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 710-13 (Nov., 1960). In Russian.

X-ray diffraction, microstructure and dilatational studies of the kinetics of the α—γ transformation in Fe—Co—V alloys (with 2.5 and 3.0% V, 52% Co) showed that ordering in the α-phase precedes and aids precipitation of the γ-phase and affects the alloy structure.

A.Tybulewicz

6533 THERMOMAGNETIC TREATMENT AND ORDERING PROCESSES. III. STUDY OF THE EFFECT OF THERMOMAGNETIC TREATMENT ON THE ELECTRICAL RESISTIVITY OF SUPERLATTICE-FORMING SOFT MAGNETIC ALLOYS.

Ya.S.Shur and A.A.Glazer.

Fiz. Metallov i Metallovedenie (USSR), Vol. 6, No. 5, 958-60 (1958). In Russian.

For Pt II, see Abstr. 9777 of 1959. Measurements of the resistivity, magnetoresistance and coercive force were made on specimens of 78-Permalloy and Perminvar at 0° C and at −196° C. From a comparison of results obtained after annealing specimens at 460° C, re-annealing them in a magnetic field of 200 Oe at 450° C and quenching them from 700° C, it is concluded that the superlattice structure is not destroyed by a magnetic anneal below the ordering temperature. Similarly, by comparing results on quenched specimens which were subsequently annealed with or without an applied magnetic field, it is concluded that the ordering kinetics is not affected by the field. These results suggest that the number of atoms which are affected by the presence of the magnetic field is too small to influence the formation of the superlattice. [English translation in: Phys. Metals and Metallography (GB), Vol. 6, No. 5, 193-5 (1958)].

R.Parker

6534 ORDERING AT LOW-TEMPERATURE ANNEALING OF QUENCHED Fe_3Al ALLOY.

Ya.P.Selisskii.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 714-19 (Nov., 1960). In Russian.

Reports a determination of the rate of cooling during quenching of the Fe_3Al alloy which is required to produce a disordered state. The electrical resistance and the lattice constant were measured as a function of the duration of annealing. A dilatometric study of the quenched and annealed states is reported. It is suggested that the changes on annealing are due to establishment of short-range order.

A.Tybulewicz

6535 TRANSFORMATION — DISORDER TO ORDER IN Ni_3Mn.

M.J.Marcinkowski and N.Brown.

J. appl. Phys. (USA), Vol. 32, No. 3, 375-86 (March, 1961).

The ordering transformation in the alloy Ni_3Mn has been investigated using both magnetic and neutron diffraction techniques. These measurements were made with alloys that were allowed to relax to nearly equilibrium states of order over a range of temperatures above and below the critical ordering temperature. In addition, the manner in which these equilibrium states were approached isothermally was also investigated over a range of temperatures. From these measurements, it has been postulated that the equilibrium configurations of partial order are nonhomogeneous, consisting of long-range ordered domains in a matrix of short-range order. In addition, the isothermal transformation from disorder to long-range order proceeds first by the development of short-range order. Both short- and long-range order have been found to increase the magnetic Curie temperature as well as the magnetization above that of the weakly magnetic disordered alloy. These results support the hypothesis that nearest neighbour magnetic-spin interactions play an important role in determining these magnetic properties, although the importance of more distant neighbour interactions cannot be ruled out.

6536 MONTE CARLO COMPUTATIONS ON THE ISING MODEL. THE BODY-CENTERED CUBIC LATTICE.

L.Guttman.

J. chem. Phys. (USA), Vol. 34, No. 3, 1024-36 (March, 1961).

The Monto Carlo method of computation is used to obtain some equilibrium properties of b.c.c. binary solid solutions whose atoms interact according to the Ising model. Four cases are treated: (a) $N = 128$, $c = \frac{1}{2}$, (b) $N = 1024$, $c = \frac{1}{2}$, (c) $N = 1024$, $c = 3/8$, and (d) $N = 1024$, $c = \frac{1}{4}$ (N being the total number of atoms and c the fraction of one kind.) In all cases the heat capacity has a well-defined maximum. At the equiatomic composition, the height of this maximum is greater in the larger crystal. Discontinuities in thermodynamic properties were not observed, and it seems reasonable that the order—disorder transition in an infinite crystal would be characterized by an infinite heat capacity as calculated by Onsager and others for two-dimensional crystals. Comparison of the results with experimental properties of β-CuZn suggests a remarkable applicability of the Ising model to this system. The potentialities and limitations of the Monte Carlo method for systems with phase transitions are discussed.

6537 STABILITY OF RETAINED AUSTENITE ON AGEING. E.G.Ramachandran and C.Dasarathy.

Acta metallurgica (Internat.), Vol. 8, No. 4, 274-5 (April, 1960).

Estimates of the speed of diffusion of carbon atoms are given and it is argued that, if deactivation of austenite strain embryos takes place (as envisaged by Cohen et al.) by the diffusion of carbon atoms towards them followed by capture, then an appreciable concentration gradient for carbon is essential in the austenite for sufficiently high diffusion rates to be achieved. The required concentration gradient, it is suggested, has to be attributed to the existing regions of martensite and not to microsegregation of carbon atoms. These concepts would together explain the effect on θ, the stability parameter, of both the proportion of adjacent athermal martensite and the ageing temperature. See also following abstract. A.E.Kay

6538 ATHERMAL STABILIZATION OF AUSTENITE. E.G.Ramachandran and C.Dasarathy.

Acta metallurgica (Internat.), Vol. 8, No. 9, 666-7 (Sept., 1960).

Extends the idea presented in a previous note (see preceding abstract). The martensite which provides the necessary concentration gradient for promoting rapid diffusion is now assumed to exist in submicroscopic form as nuclei. Using experimental data it is deduced that, with normal quenching media such as salt and oil baths and air cooling, stabilization would occur only within a temperature range of about 200° to 350° C. Results are quoted for two chromium steels and a nickel steel which stabilize respectively in the ranges 180°-350° C and 300°-400° C. A.E.Kay

6539 HYDROGEN AND AUSTENITE STABILIZATION. E.G.Ramachandran and C.Dasarathy.

Acta metallurgica (Internat.), Vol. 8, No. 10, 729-30 (Oct., 1960).

Consideration is given to the possibility that hydrogen may play a major part in the stabilization of austenite. It is concluded that the amounts of hydrogen present in normal heat-treated steels are insufficient to account for the de-activation of the "strain embryos" in austenite which is the mechanism proposed for stabilization. J.Thewlis

6540 A STUDY OF AGEING OF DURALUMIN USING NUCLEAR MAGNETIC RESONANCE. V.S.Pavlovskaya,

V.N.Podd'yakov and B N.Finkel'shtein.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 3, 346-9 (Sept., 1960). In Russian.

Measurements were made of nuclear magnetic resonance absorption intensity, line-widths and profiles. The effect of quadrupole resonance on the lines was studied and qualitative conclusions are drawn about distortions in the crystal lattice due to regrouping of the component atoms of the alloy during ageing. A.Tybulewicz

6541 RECRYSTALLIZATION OF POWDERS OF PURE METALS. V.I.Iveronova and N.N.Osipenko.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 736-42 (Nov., 1960). In Russian.

Reports a study of polygonization and recrystallization in deformed powders and bulk samples of copper and aluminium. Annealing of powders at low temperatures (in the case of copper, room temperature is sufficient) produced polygonization which reduced the mean dimensions of mosaic blocks, removed stresses of type II, and produced points on Debye diffraction lines due to reflections from well-formed blocks. Polygonization delayed considerably completion of recrystallization in powders, compared with recrystallization of bulk samples. A.Tybulewicz

6542 PRECIPITATION IN GOLD—NICKEL SINGLE CRYSTALS. P.J.Flanders and F.R.L.Schoening.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 344S-345S (March, 1961).

Magnetic, X-ray and microscope examinations were made on single-crystal disks of a Au—Ni alloy containing 24.8 at.% nickel to investigate the precipitation process. The precipitation begins on the surface at discrete areas which grow broader and deeper as annealing progresses. Magnetic data can be interpreted by assuming that the Ni-rich precipitate is elongated in the $\langle 111 \rangle$ directions, electron micrographs indicating the presence of elongation. The Ni-rich phase acquires a small degree of crystalline orientation with increased annealing, whereas the Au-rich phase maintains an appreciable amount of orientation throughout .

6543 DIFFUSION REACTIONS IN THE AGING OF 4-79 MOLYBDENUM PERMALLOY.

E.M.Tolman.

J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 360S-361S (March, 1961).

Measurements of coercive force have been used to follow the low-temperature ageing of 4-79 molybdenum Permalloy twistor wire. Twistor wire samples were annealed for varying periods of time at temperatures ranging from 119 to 300° C. This treatment resulted in decreases in coercive force with time which indicated the presence of three distinct reactions. The first reaction, associated with a stress relief anneal, was too rapid to measure. A second reaction, characterized by an exponential decrease in coercive force over the 119-200° C range, was found to fit first-order behaviour at 119° C. Its energy of activation was found to be 35.8 kcal/mole or about 1.6 eV. This is the same value as that obtained by Clarebrough from release of energy studies below 300° C as the energy for the disappearance of vacancies in plastically deformed nickel. The 4-79 diffusion reaction appears to result from the same cause. From 119 to 300° C, evidence of a rapid third reaction was observed. Polygonization, as found in an X-ray examination of cold-worked 4-79 alloy heated at 400° C, appears to explain the development of a second easy direction of magnetization in the material.

6544 RADIATION-ENHANCED HELIUM PRECIPITATION IN COPPER. A.N.Goland.

Phil. Mag. (GB), Vol. 6, 189-93 (Feb., 1961).

The effect of neutron irradiation on the precipitation of helium atoms in copper was studied at temperatures up to 425° C. At 160° C and 300° C no effect was observed. At 425° C the irradiated sample exhibited considerable precipitation around grain boundaries as compared to an unirradiated sample held at the same temperature. It is concluded that the additional vacancies introduced during the irradiation enhance the precipitation process. The resultant voids are equal in size to those obtained at higher temperatures in the absence of radiation.

6545 MODIFICATION OF BERYLLIUM AND CHROMIUM STRUCTURE BY MEANS OF ULTRASONIC IRRADIATION DURING ARC MELTING.

B.E.Popov, S.F.Kovtun and V.M.Amonenko.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 6, 853-6 (Dec., 1960). In Russian.

Beryllium and chromium were irradiated during arc melting using a source of 19.7 kc/s frequency and 2 kW power. This reduced considerably their crystal grain size. A.Tybulewicz

6546 NOTE ON THE INTERACTION OF INTERSTITIALLY DISSOLVED CARBON ATOMS IN α-IRON.

A.J.Bosman, P.E.Brommer, L.C.H.Eykelenboom, C.J.Schinkel and G.W.Rathenau.

Acta metallurgica (Internat.), Vol. 8, No. 10, 728-9 (Oct., 1960).

It is shown that in the case of interstitially dissolved C in α-Fe, the previously observed relaxation phenomena at times very long compared with the relaxation time due to single jumps of the interstitial atoms, are mainly due to interaction of these atoms. J.Thewlis

6547 CONFIGURATIONAL FREE ENERGY OF A MULTI-COMPONENT SOLID SOLUTION WITH ALLOWANCE FOR INTERSTITIAL ATOMS. A.N.Men'.

Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 4, 630-1 (Oct., 1960). In Russian.

Gives an expression for the configurational energy in terms of the energies of interaction of pairs of different atoms at different distances from one another. A.Tybulewicz

6548 CALCULATION OF CORRELATION PARAMETERS FOR THE SECOND CONFIGURATION SPHERE IN AN N-COMPONENT SOLID SOLUTION.

A.N.Men'.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 655-60 (Nov., 1960). In Russian.

Considers a disordered solid solution and calculates the correlation parameters, allowing for atoms at interstitial positions.

A.Tybulewicz

6549 EQUILIBRIUM ATMOSPHERE SCHEDULES FOR THE COOLING OF FERRITES.

J.M.Blank.
J. appl. Phys. (USA), Suppl. to Vol. 32, No. 3, 378S-379S (March, 1961).

Phase diagrams including contour lines of constant ferrous ion content in oxygen partial-pressure versus temperature coordinates were determined for two MnZn ferrites and two NiZn ferrites containing excess iron. A "universal" equilibrium atmosphere diagram which is applicable to a wide variety of ferrites was synthesized from these data. This diagram specifies the schedules of temperature and percent oxygen by which ferrites can be cooled from the sintering temperature without net gain or loss of oxygen.

OTHER SOLID FORMS

6550 COMPOSITION REQUIREMENTS FOR GLASS FORMATION IN METALLIC AND IONIC SYSTEMS.

M.H.Cohen and D.Turnbull.
Nature (GB), Vol. 189, 131-2 (Jan. 14, 1961).

The report of Klement, Willens and Duwez [Nature (GB), Vol. 187, 869 (Sept. 3, 1960)] of the formation of glass by a gold—silicon alloy by cooling the melt, is shown to be in accordance with the authors' theory of glass formation.

D.M.Schlapp

6551 GLASS FORMATION IN SOLUTIONS OF HYDROGEN PEROXIDE—WATER AND DEUTERIUM PEROXIDE—HEAVY WATER.

R.C.Smith and S.J.Wyard.
Nature (GB), Vol. 189, 211-12 (Jan 21, 1961).

The authors claim to have formed glasses from these two solutions by allowing them to fall as drops on to the surface of liquid oxygen, or by placing in a tube which is then plunged into liquid oxygen. Glass is formed over quite a wide range of composition in the case of the hydrogen-peroxide—water solution.

D.M.Schlapp

A REVIEW OF AMORPHOUS SEMICONDUCTORS. See Abstr. 6137

INFRARED SPECTROSCOPY OF MELTS AND HYGROSCOPIC GLASSES. See Abstr. 5346

MAGNETIC RESONANCE OF PROTONS IN GLASSES. See Abstr. 6436

VITREOUS FORM OF ICE. See Abstr. 6518

6552 SIGNIFICANCE OF THE PROPERTIES OF MATERIALS IN THE PACKING OF REAL SPHERICAL PARTICLES.

J.C.Macrae and W.A.Gray.
Brit. J. appl. Phys., Vol. 12, No. 4, 164-72 (April, 1961).

Measurements of the packing of spherical particles poured into a cylindrical container show that the intensity of deposition, the height of drop and the elasticity of the particle material influence the packing equally. Minor departures from perfect sphericity tend to mask the influence of elasticity. Optimum packing of poured spherical particles occurs when the energy increment imparted to the bed by each impacting particle exceeds a critical value, the rate of renewed application of increments is above a critical value and the intensity of deposition is below a critical level. Within a critical range of deposition conditions, sufficient energy may be imparted to spherical particles to activate a process of ordered packing, initiated at a wall. These conditions are fulfilled when 0.125 in. diameter spheres fill at 3 in. diameter glass cylinder at 1400 particles per second with impact velocities greater than $120/\{\frac{1}{2}(1 + e_m)\}^{12}$ in./sec, e_m being the resilience of the particle material. Determinations of wall effects show that these conclusions and the derived mechanism of packing are valid for the packing of an infinitely extensive bed.

6553 PACKING OF SPHERES.

G.D.Scott.
Nature (GB), Vol. 188, 908-9 (Dec. 10, 1960).

"When spherical balls are poured into rigid containers there appears to be a range of random packing densities possible, with the upper limit at 0.63(7) and the lower limit at 0.60(1). It seems unlikely that there are other stable random packing arrangements for equal spheres which have packing densities outside these limits". These conclusions result from observations on packing of steel balls in spherical flasks, balloons and dimpled copper cylinders, the results being extrapolated to assemblies of infinite size, numerical agreement being satisfactory. There appear to be two quite distinct modes of random packing. By careful control of the filling process a "pure" specimen of either mode can be obtained fairly easily.

H.N.V.Temperley

6554 CO-ORDINATION OF RANDOMLY PACKED SPHERES.

J.D.Bernal and J.Mason.
Nature (GB), Vol. 188, 910-11 (Dec. 10, 1960).

Describes a study of the coordination numbers associated with the two modes of packing described by Scott (see preceding abstract). The number of "close" and "near" contacts were determined by flooding the assembly with paint, which is afterwards drained away. Surface tension ensures that it will cling to two spheres that are in contact or nearly so. The numerical results are compared with the conclusions drawn from other work. The physical interpretation of the "loose" mode of random packing found by Scott is not yet clear.

H.N.V.Temperley

6555 MAGNETIC STUDY OF THE COATING OF TUNGSTEN CARBIDE GRAINS WITH A THIN COBALT SKIN.

M.Toitot.
C.R. Acad. Sci. (France), Vol. 251, No. 14, 1362-4 (Oct. 3, 1960). In French.

Powders intended for sintered or fired carbides need to be fine, homogeneous and of controlled grain size. It is shown that these quantities can be controlled by measurement of the magnetic properties of the powders.

S.A.Ahern

6556 THE KINETICS OF SINTERING IN THE SOLID PHASE.

B.Ya.Pines.
Fiz. Metallov i Metallovedenie (USSR), Vol. 10, No. 5, 750-5 (Nov., 1960). In Russian.

Lifshits and Slezov (Abstr. 2956 of 1959) describe sintering which is different from the usual process in ceramics and cermets. It is shown that in the case of Lifshits—Slezov sintering the decomposition of a saturated solution of vacancies and coalescence of pores are important; in the usual sintering the effect of pore coalescence is not great and there is no saturation with vacancies. The author proposes to call the Lifshits—Slezov sintering "precipitation sintering".

A.Tybulewicz

6557 FINELY GROUND QUARTZ: EVIDENCE AGAINST A "DISTURBED" LAYER.

J.H.Talbot and E.B.Kempis.
Nature (GB), Vol. 188, 927-9 (Dec. 10, 1960).

The observation that the rate of solution of a finely-ground quartz powder decreases from an initially high value to a steady, lower value has led to speculation as to the nature of these particles. It has been proposed for example that the particles are surrounded by a "flow layer" of amorphous silica. The authors tested some of these theories by using electron diffraction to compare the state of finely-ground quartz powder before and after leaching in 20% hydrofluoric acid. It is concluded that previous theories are not supported by the results. The authors put forward their own theory that tiny particles, clinging to the larger ones, would provide an adequate explanation for the phenomena observed.

A.E.I. Research Laboratory

6558 POROSITY AND SURFACE AREA OF A GRANULAR BED FROM MEASUREMENTS OF THE FLOW OF AIR THROUGH THE BED AND MEASUREMENTS OF THE GRANULAR SHAPE FACTORS.

W.M.Jones and D.Mills.
Brit. J. appl. Phys., Vol. 12, No. 4, 172-4 (April, 1961).

Flow experiments give an equation relating ϵ to S in terms of measurable quantities, where ϵ is the inter-granular porosity of the bed, and S is the envelope surface area of the granules in 1 cm^3 of bed. Heywood's shape factors for the granules give a second equation relating ϵ to S. Using the two equations ϵ and S can be determined uniquely. If the tortuosity factor be taken to be $\pi/2$ in the equations given previously (Abstr. 779 of 1957), connecting the friction factor λ and the Reynolds number Re, then $\lambda = \cdot 16/Re$ for granular beds, as for long straight tubes.

Surfaces . Films . Adsorption

6559 METHOD FOR MEASURING THE FREE ENERGY OF A SOLID SURFACE. M.J.Fraser.

Acta metallurgica (Internat.), Vol. 8, No. 10, 732-4 (Oct., 1960).

The method is applicable only to solids that evaporate by a lamellar mechanism. It is based on an analysis of the equilibrium between the evaporation of a lamellar plane and its "locking" by inclusions. J.Thewlis

6560 FORMATION OF PHOSPHOR FILMS BY EVAPORATION. L.R.Koller and H.D.Coghill.

J. Electrochem. Soc. (USA), Vol. 107, No. 12, 973-6 (Dec., 1960).

Three processes for making ZnS phosphor films are described. One process for ZnS activated with Cu, Ag, or Mn involves evaporation of powder phosphor onto a room-temperature substrate followed by heat treatment of the film in an $H_2S + HCl$ atmosphere. A process for ZnS:Mn along involves the single step of evaporating the phosphor onto a substrate held between 250° and 400° C. The third process involves evaporating the phosphor in a single step onto a heated substrate in a uniformly heated enclosure such as the "hot wall bell jar". A fourth process used for silicate, phosphate, and borate phosphors involves a reaction during the course of evaporation between ZnF_2 and a heated substrate.

6561 THE ANOMALIES PRODUCED BY CRACKS IN THIN LOW-TEMPERATURE EVAPORATED Ag AND Pb-FILMS IN RELATION TO THE CHANGES IN CONDUCTIVITY CAUSED BY TEMPERING. A.Dévényi.

Rev. de Physique (Roumania), Vol. 5, No. 1, 23-31 (1960). In German.

The films were evaporated on to glass at -130° C and then heated. The electrical resistance R(T) as a function of temperature T was measured and the films examined by electron microscopy in order to establish the causes of the anomalies previously observed (Abstr. 11597 of 1959) in the R(T) curves for several metals and which occur particularly for Ag. In the Ag films granulation takes place between -50 and 20° C and cracks cannot be entirely avoided. The cracks, which are the result of the stresses produced in the films by the contraction during the heat treatment, are the primary cause of the anomalies. S.Weintroub

6562 VACUUM DEPOSITION OF DIELECTRIC FILMS FOR CAPACITORS. G.Siddall.

Vacuum (GB), Vol. 9, No. 5-6, 274-87 (Nov. 1959-Jan., 1960).

The first part of this work deals with the evaporation of inorganic materials suitable for making thin dielectric layers for capacitors. The evaporation of a mixture of oxides, for example a glass, is also discussed, and the electrical properties of some glasses are given. The stability of metal oxide compounds at high temperatures is considered in relation to their free energies of formation. The reported vapour pressures of the components of the more commonly used glasses show that their evaporation is not possible from a single vapour source without separation of the components by fractional distillation. The second part of the report describes an experimental investigation into the preparation and properties of dielectric films of silicon oxide in the thickness range 0.14 to 1.7 μ produced by the evaporation of silicon monoxide at varying rates. Capacitors of 0.001-0.01 $\mu F/cm^2$ have been deposited on Pyrex glass using evaporated aluminium films for the conducting-plates, and measurements of the electrical properties of the silicon oxide films have been made. The working voltage of capacitors in this range lies between about 12 and 60 V depending upon the thickness of the dielectric and upon the working temperature. At temperatures above 200° C the values of loss angle and leakage current are generally unacceptable. It is established that the rate of deposition of the oxide layer has a marked effect on the loss angle, dielectric constant and leakage current. Generally the lowest values of leakage current and loss angle are obtained with rates of deposition below 5 A/sec. The dielectric constant of slowly deposited silicon oxide films is less than that of bulk silica, which is attributed partly to their lower density. The work carried out with silicon oxide shows that satisfactory dielectric films for capacitors can be made by the evaporation technique.

DEPOSITION OF FILMS BY EVAPORATION IN A VACUUM. See Abstr. 5315

NEW INTERPRETATION OF THE SUBSTRUCTURE OF ELECTROPOLISHED ALUMINIUM SURFACES. See Abstr. 6491

VARIATION OF TRITIUM CONCENTRATION WITH DEPTH IN TITANIUM TRITIDE FOILS: STUDY USING THE $H^3(d, n)He^4$ REACTION. See Abstr. 5792

6563 TESTS FOR CHEMISORPTION OF NITROGEN ON A CLEAN (100) NICKEL SURFACE.

H.H.Madden and H.E.Farnsworth.

J. chem. Phys. (USA), Vol. 34, No. 4, 1186 (April, 1961).

Tests were made for chemisorption of nitrogen on the (100) surface of a nickel crystal, using low-energy electron diffraction and photoelectric work-function determinations. No chemisorption was observed after exposures as high as 10^{-3} mm Hg min at room temperature or at 350° C.

MICROSTRUCTURE EXAMINATION

(By X-rays and Electron and Other Microscopes)

6564 THE INVESTIGATION OF SURFACE DEFORMATION. L.Grunberg, D.Scott and K.H.R.Wright.

Brit. J. appl. Phys., Vol. 12, No. 4, 134-40 (April, 1961).

"Non-Destructive Testing" Conference, London, May, 1960 (see Abstr. 5132 of 1961). The methods for studying surface deformation used in the National Engineering Laboratory are described. Deformed metal surfaces show an enhanced photoelectric emission which is studied with the aid of open-ended Geiger—Müller counters or electron multipliers. Oxide films stripped from deformed metal surfaces are studied by electron microscopy and changes in chemical reactivity by radioactive tracers. Surface topography is an important factor in lubrication and wear research and is being studied with the aid of interferometry, phase contrast and electron microscopy. Replica techniques are often applied with advantage.

6565 SMALL-ANGLE INTENSITIES FROM DOUBLE BRAGG REFLECTIONS IN COLD-WORKED METALS.

B.E.Warren.

Austral. J. Phys., Vol. 13, No. 2a, 376-83 (July, 1960).

Solid State Physics Conference (see Abstr. 17864 of 1960). The small-angle intensity from a cold-worked polygrained metal is treated in terms of double Bragg reflections. It is assumed that cold work breaks up the original grains into subgrains with varying orientations, such that a first reflection in one subgrain can be followed by a second reflection in another subgrain of the original grain. For an initial sample which is polygrained with random orientation, the small-angle intensity resulting from cold work is given in absolute units in terms of two parameters: an average initial grain size G, and a subgrain correlation function $p(\varphi)$ giving the distribution in orientation of subgrains with respect to any average subgrain of the original grain. Under favourable conditions, both of these quantities can be obtained from the small-angle intensity curve. For polygrained metals, small-angle scattering is a useful tool for obtaining the subgrain correlation function $p(\varphi)$, a quantity not obtainable from the usual high-angle measurements.

6566 SMALL-ANGLE SCATTERING OF X-RAYS FROM DEFORMED NATURAL GRAPHITE. E.Matuyama.

Nature (GB), Vol. 188, 218-19 (Oct. 15, 1960).

Ceylon graphite powder was deformed by the techniques of rolling, extruding, pressing, and lamellar compounding with bromine and potassium, the bromine and potassium subsequently being driven off by heating. A slit-collimated X-ray powder-diffraction camera was used, operating under constant exposure conditions for all specimens, and having a rotating film-holder to enable all exposures to be made on the same piece of film. The crystallites in the flat specimens were preferentially oriented so that the layer planes were perpendicular to the incident beam. Cobalt radiation was used, filtered through Ross-type filters. The (log scattered intensity) versus (log scattering angle) curves are virtually linear and parallel from which the "p" and "L" values for the variously deformed crystallites are calculated. The angle dependence of the scattered intensity was found to be $(2\theta)^{-2.5}$ corresponding to $(2\theta)^{-3.5}$ for a pinhole-collimated camera. R.V.Coates

PHYSICAL CHEMISTRY

QUANTUM CHEMISTRY SUMMER INSTITUTE. See Abstr. 5959

THERMOCHEMISTRY . REACTIONS

6567 SLOWLY REACTING GAS MIXTURE IN A HEAT CONDUCTIVITY CELL. D.Secrest and J.O.Hirschfelder.

Phys. of Fluids (USA), Vol. 4, No. 1, 61-73 (Jan., 1961).

A hypothetical gas mixture composed of A_2, B_2, and AB which reacts bimolecularly, $2AB \rightleftharpoons A_2 + B_2$, is placed in a thermal conductivity cell. The heat flux as well as the chemical and thermal profiles are calculated numerically for fast, slow, and intermediate reaction rates. Since the chemical composition is not in equilibrium with the local temperature, considerable calculational difficulties are encountered. An approximation scheme is given for estimating the behaviour of such systems. It is found that for fast reactions, local equilibrium applies. If the rate of the chemical reactions is slow compared to the rate of diffusion (an exact criterion is given), the chemical composition within the cell becomes homogeneous throughout the cell. This composition is determined by the set of equations.

$$\int_{T_C}^{T_H} \lambda R_i dT = 0,$$

where λ is the coefficient of heat conductivity and R_i is the net rate of production of molecules of the ith species. Conversely, from a knowledge of the steady-state chemical composition one may determine the chemical reaction rates. Calculations are made for a mixture of H_2I_2, and HI. This system should be easy to study experimentally since the I_2 concentration can be determined from optical absorption and the HI concentration can be determined from infrared absorption.

CHEMICAL REACTIONS IN CROSSED MOLECULAR BEAMS. See Abstr. 6064

6568 KINETICS OF COORDINATE BOND FORMATION. IV. KINETIC ISOTOPE EFFECT IN THE REACTION $NH_3 + BF_3$. G.B.Kistiakowsky and C.E.Klots.

J. chem. Phys. (USA), Vol. 34, No. 3, 712-14 (March, 1961).

For Pt III, see Abstr. 12850 of 1959. An isotopic rate ratio, k'/k = 1.91 ± 0.10, was measured at room temperature for the reactions $NH_3(ND_3) + BF_3 = NH_3BF_3(ND_3BF_3)$. A set of vibrational frequencies for the transition states is deduced which explains the observation by attributing to the transition state a large degree of charge transfer stabilization and a negligible activation energy.

6569 KINETICS OF COORDINATE BOND FORMATION. V. KINETICS OF THE REACTION $P(CH_3)_3 + BF_3$.

G.B.Kistiakowsky and C.E.Klots.
J. chem. Phys. (USA), Vol. 34, No. 3, 715-17 (March, 1961).

The temperature pattern method in dilute spherical diffusion flames was applied to the reaction of boron trifluoride with trimethyl phosphorus. The bimolecular rate constant indicates this to be the fastest association reaction yet studied with this technique. Expectations as to the effect of the reverse reaction on the temperature pattern are qualitatively confirmed. The origin of steric factors in coordinate bond formation is briefly discussed.

6570 ON THE ISOMERIZATION OF n-BUTYL RADICALS. A.S.Gordon and J.R.McNesby.

J. chem. Phys. (USA), Vol. 33, No. 6, 1882-3 (Dec., 1960).

The isotopic content of the methane fraction produced by reaction of CD_3 with $CH_3CD_2CD_2CH_3$ shows that the isomerization reaction involving shift of a D atom along the carbon chain does not occur before the C—C rupture. G.I.W.Llewelyn

OXIDATION OF ARMCO IRON. See Abstr. 6112

ENERGY TRANSFER TO A RIGID PISTON UNDER DETONATION LOADING. See Abstr. 4371

ELECTROCHEMISTRY

6571 TRANSIENT STRAIN-INDUCED ELECTRODE POTENTIALS. K.Nobe, E.Baum and W.F.Seyer.

J. Electrochem. Soc. (USA), Vol. 108, No. 1, 97-100 (Jan., 1961).

Transient potentials produced when copper and zinc-plated copper wires are strained elastically in $CuSO_4$ and $ZnSO_4$ solutions, respectively, were investigated. The potential response on loading was instantaneous and decayed back to the original value within several seconds. The unloading response was similar to loading but of opposite sign. The amplitude of response was approximately proportional to the load. Theoretical considerations of the electrical double layer predict the experimental results obtained.

HIGH CURRENT ELECTRONIC POTENTIOSTAT. See Abstr. 4538

6572 A CONTRIBUTION TO THE STUDY OF ELECTROLYSIS BY A FLUCTUATING CURRENT.

V.Mercea, I.Ursu and G.Văsaru.
Stud. Cercetari Fiz. (Roumania), Vol. 8, No. 4, 479-89 (1957).
In Roumanian.

The note follows earlier work on the study of the phenomenon of the polarization of electrodes in the dynamic regime for $CuSO_4$. The present work reports a study of this polarization for various ions and using various alloys for electrodes. An experimental method was devised which allows the measurement of the polarization at the electrodes more precisely than with previous methods. A polarization limit for fluctuating current, whose magnitude depends on the nature of the electrode and the direct current component, was found. R.D.Smith

PHOTOCHEMISTRY RADIATION CHEMISTRY

6573 VACUUM ULTRAVIOLET PHOTOLYSIS OF ETHANE: MOLECULAR DETACHMENT OF HYDROGEN.

H.Okabe and J.R.McNesby.
J. chem. Phys. (USA), Vol. 34, No. 2, 668-9 (Feb., 1961).

The primary process of direct ethane photolysis of Xe radiation (1470 A and 1295 A) was studied at room temperature. The hydrogen and methane isotopic compositions from a mixture of $C_2H_6-C_2D_6$ and from CH_3CD_3 were measured mass-spectrometrically. The results show that, contrary to the previously proposed mechanism, almost all (>95%) of the hydrogen is formed intramolecularly, and preferentially from the same carbon atom. Methane is also formed by a molecular process. Then the primary processes may be written as

$$C_2H_6 \rightarrow CH_3CH + H_2$$
$$C_2H_6 \rightarrow C_2H_4 + H_2$$
$$C_2H_6 \rightarrow CH_4 + CH_2.$$

The absence of C_2D_6 in the products of the photolysis of CH_3CD_3 places an upper limit on $\varphi_{CD_3}/\varphi_{CD_3H + CH_3D}$ of about unity assuming all methyl radicals form ethane by recombination. The effect of the product ethylene on the composition of hydrogen isotopes from $C_2H_6-C_2D_6$ mixtures was examined, since any atomic hydrogen produced may be reacting rapidly with ethylene. The sample was purified and very low conversion (0.01%) was made. The result shows almost no change in the composition of the hydrogen isotopes in the products, indicating that the hydrogen forming step is largely molecular. It is suggested that higher hydrocarbons may be produced by the following reactions

$$CH_2 + C_2H_6 \rightarrow C_3H_8$$
$$CH_3CH + C_2H_6 \rightarrow C_4H_{10}.$$

6574 PHOTOCHEMICAL STUDIES IN FLASH PHOTOLYSIS. II. PHOTOLYSIS OF ACETONE WITH FILTERED LIGHT. N.Slagg and R.A.Marcus.

J. chem. Phys. (USA), Vol. 34, No. 3, 1013-17 (March, 1961).

For Pt I, see Abstr. 8920 of 1957. Flash photolysis was studied in the absence of wavelengths below 200 mμ. Effects of acetone pressure, light intensity, added biacetyl, temperature, and wavelength were investigated. The results are consistent with primary acts postulated previously on the basis of low-intensity studies, but with the absence of complicating first-order secondary reactions at these high radical concentrations. Deactivation of excited molecules explains the pressure effect on the C_2H_6/CO ratio, for wall effects are absent under flash conditions. A hot radical mechanism is suggested by the data for methane formation. The effect of wavelength on C_2H_6/CO ratio in regions centred near 260, 280, and 295 mμ is rather striking, and the results are compared with trends in low-intensity studies in the same pressure region.

6575 THE PHOTOLYSIS OF NITROUS OXIDE IN THE FAR ULTRAVIOLET. W.E.Groth and H.Schierholz.

Planet Space Sci. (GB), Vol. 1, No. 4, 333-42 (Sept., 1959).

The photolysis of nitrous oxide was studied in a flow system using xenon resonance radiation at 1470 and 1295 A and krypton resonance radiation at 1236 and 1165 A. The average quantum yields with regard to decomposed nitrous oxide, nitrogen and higher oxides of nitrogen were found to be larger in the experiments using the longer wavelengths than in the experiments using the 1236 and 1165 A radiation. The ratio of the quantum yield with respect to oxygen and nitrogen was found to be lower in the experiments with the resonance radiation of xenon than in the experiments with the resonance radiation of krypton. From the data obtained, it can be assumed that at the xenon resonance radiation the initial absorption of a light quantum leads to the production of nitrogen molecules and oxygen atoms. At the shorter wavelengths, the initial absorption act probably proceeds in a dual manner. It is supposed that both the splitting of nitrous oxide into nitrogen molecules and oxygen atoms and into nitrogen atoms and nitric oxide occurs at this radiation.

6576 PHOTOCHEMICAL FORMATION OF ORGANIC COMPOUNDS FROM MIXTURES OF SIMPLE GASES.

W.E.Groth and H.v.Weyssenhoff.

Planet. Space Sci. (GB), Vol. 2, No. 2-3, 79-85 (April, 1960).

Experiments are described on photochemical reactions in mixtures of methane or ethane with ammonia and water vapour which were irradiated with light of extremely short wavelengths. Both mercury-sensitized and direct photolysis experiments were carried out. Sensitized experiments with a mixture of methane, ammonia and water vapour did not yield any reaction products. Amino acids, low fatty acids and liquid hydrocarbons were obtained when methane was replaced by ethane. Amino acids and fatty acids were quantitatively determined. In direct photolysis experiments with mixtures of methane, ammonia and water vapour, using the resonance radiation of xenon, glycine was formed which was detected by paper chromatography. The relation of these experiments to the photochemical processes in the atmosphere of the earth in its early stages is briefly discussed.

ABSORPTION AND PHOTOCHEMISTRY OF AgCl CRYSTALS CONTAINING DIVALENT CATIONS AND ANIONS. See Abstr. 5046

6577 RADIOLYSIS OF AQUEOUS SOLUTIONS HIGHLY ENRICHED IN O^{18}.

M.Anbar, S.Guttmann and G.Stein.

J. chem. Phys. (USA), Vol. 34, No. 3, 703-11 (March, 1961).

Solutions of $H_2O_2^{16,16}$ in water highly enriched in O^{18} were irradiated with X-rays and protons. The effects of H_2O_2 concentration, pH, bromide and nitrite ions, on the yield of the isotopic species $H_2O_2^{16,18}$ and $H_2O_2^{18,18}$, were investigated. The "molecular" H_2O_2 is formed with a G value of 0.3 in neutral solutions. The formation of $H_2O_2^{16,18}$ is attributed to the attack of $O^{18}H$ radicals on $H_2O_2^{16,16}$. The evolved $O_2^{16,18}$ may be regarded as a product of a parallel reaction. The yield of $O_2^{16,18}$ is dependent on an exchange reaction between HO_2 and H_2O_2. Specific effects due to added NO_2^- and high concentrations of Br^- are discussed.

PROBABILITY DISTRIBUTION OF RECOIL ENERGY IN NEUTRON-CAPTURE GAMMA-RAY EMISSION. See Abstr. 4179

ENERGY TRANSFER MECHANISMS IN THE RADIATION CHEMISTRY OF LIQUIDS: RELATION TO LUMINESCENCE DECAY TIMES. See Abstr. 5279

DISPERSIONS . COLLOIDS

6578 KINETICS OF ULTRASONIC FOG FORMATION. L.D.Rozenberg and O.K.Éknadiosyants.

Akust. Zh. (USSR), Vol. 6, No. 3, 370-3 (1960). In Russian.

Fog was ejected from an ultrasonic fountain in separate bursts of 400 μsec duration, the intervals between bursts being much longer. The bursts could be narrow or wide, directed or otherwise. Fog formation was always preceded by increase of transparency of fountain drops which were deformed after ejection. [English translation in: Soviet Physics—Acoustics (USA), Vol. 6, No. 3, 369-74 (Jan.,-March, 1961)]. A.Tybulewicz

6579 SMALL ANGLE X-RAY SCATTERING STUDY OF SODIUM MONTMORILLONITE CLAY SUSPENSIONS.

R.Hight, Jr, W.T.Higdon and P.W.Schmidt.

J. chem. Phys. (USA), Vol. 33, No 6, 1656-61 (Dec., 1960).

Suspensions of montmorillonite clay with concentrations of $\frac{1}{2}$ and 2% were investigated by small angle X-ray scattering, with two different centrifuge fractions being studied for each concentration. At a given concentration the scattering was observed to be the same for both centrifuge fractions. The scattered intensity was always proportional to the concentration. These results are what would be expected from dilute suspensions of thin platelets of identical thickness but different surface areas. When corrections for the finite height of the collimating slits are applied to the scattering curves, good agreement with the theoretical curves for thin platelets is obtained. From the deviation between the experimental and the theoretical curves at the largest observed scattering angles, the thickness of the platelets was calculated to be 9 A. An independent determination of the thickness can be made from a measurement of the zero angle scattered intensity from some material for which the ratio of the scattered intensity to the scattering from a single electron can be calculated. Two heavy gases, SF_6 and $C_2Cl_2F_4$ (Freon 114), were used for this purpose. The feasibility of using Ludox colloidal silica as a third standard was investigated. Within experimental accuracy, the thickness values calculated from these data agree with the values obtained from the shape of the scattering curves. Both values agree with the thickness determined from the light scattering experiments of M'Ewen and Pratt (1957). Since the scattering curve for the clay is proportional to the inverse square of the angle at the smallest observed angles, the large dimensions of the particle must be at least 500 A.

6580 NUCLEAR MAGNETIC RELAXATION IN COLLOIDAL SOLUTIONS.

G.Bonera, L.Chiodi, G.Lanzi and A.Rigamonti.

Nuovo Cimento (Italy), Vol. 19, No. 2, 234-8 (Jan. 16, 1961).

Nuclear relaxation times T_1 and T_2 were measured for solutions of isinglass and silica gel in water. The presence of more than one longitudinal relaxation time was found in these solutions. Information about the lifetime of water molecules in the absorbed phases is thus obtained.

PHYSICAL METHODS OF CHEMICAL ANALYSIS

6581 RADIOACTIVATION ANALYSIS OF OXYGEN IN SILICON BY IRRADIATION WITH α-PARTICLES IN A CYCLOTRON. T.Nozaki, S.Tanaka, M.Furukawa and K.Saito

Nature (GB), Vol. 190, 39-40 (April 1, 1961).

Describes the determination of oxygen contacts as low as 0.3 p.p.m. in transistor-grade silicon using the reaction $O^{16}(\alpha,pn)F^{18}$ The oxygen contact is calculated from the disintegration rate of F^{18}. Radioactivation analysis using the reactions $O^{16}(t,n)F^{18}$, $O^{16}(\gamma,n)O^{15}$, and $O^{17}(d,n)F^{18}$ was tried, with unsatisfactory results. Oxygen contents of as low as 10^{-3} p.p.m. can be determined by the present method.

6582 THE EVALUATION OF QUANTITATIVE SPECTRAL DATA WITH A NEW CALCULATOR. G.Müller-Uri.

Exper. Tech. der Phys. (Germany), Vol. 8, No. 4, 177-87 (1960). In German.

Examples of the use of a previously described slide-rule calculator [Wadewitz, Proc. Colloquium Spectroscopicum VI, 430 (1956)] for conversion of photographic plate densities to percentage composition. G.F.Lothian

GEOPHYSICS

6583 ON THE DETERMINATION OF THE COEFFICIENT OF TORSION OF THE EÖTVÖS BALANCE. NEW PROCEDURE. A.Norinelli.
RC Accad. Naz. Lincei (Italy), Vol. 28, No. 6, 807-13 (June, 1960).
In Italian.

Suggests that the determining measurement should be that of the variation of the distance between the weight and the lead sphere, and that the method is accurate. J.M.Hough

6584 COMMENTS ON "PROPAGATION OF INTENSE SHOCK WAVES INTO THE EARTH". J.W.Miles.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 360 (March, 1961).

A brief note, substantially as follows. The results obtained by Serbin on compaction shock waves (see Abstr. 19280 of 1960) are in disagreement with those obtained for the same model by Salvadori et al., and by the author. This disagreement appears to stem from the fact that Serbin equates the pressure just back of the shock wave to the pressure at the free surface, thereby neglecting the momentum of the compacted material. This is apparantly due to the assumption that the disturbance in the elastic, compacted material would be a simple wave of the form $f(t - x/c_1)$. Such a solution, although appropriate for a semi-infinite elastic medium, neglects the elastic wave that must be reflected at the shock wave separating the compacted and uncompacted phases.

6585 GROUP AND PHASE VELOCITIES FOR RAYLEIGH WAVES OF PERIOD GREATER THAN 380 SECONDS.
J.Brune, M.Ewing and J.Kuo.
Science (USA), Vol. 133, 757-8 (March 17, 1961).

Recent theoretical and experimental investigations of the periods of free spheroidal oscillation of the earth have shown good agreement. These data are used to determine group and phase velocities for Rayleigh waves of period greater than 380 seconds. The velocities so obtained are compared with those determined from analysis of progressive waves. It is concluded that group and phase velocities determined by either of the two methods are in agreement.

RADIO-WAVE PROPAGATION IN THE EARTH'S CRUST. See Abstr. 5602

ISOTOPIC COMPOSITION OF XENON FROM ENSTATITE CHONDRITES. See Abstr. 4918

ATMOSPHERE

(Troposphere and Stratosphere)

6586 NITRIC OXIDE AND MOLECULAR OXYGEN IN THE EARTH'S UPPER ATMOSPHERE.
A.S.Jursa, Y.Tanaka and F.LeBlanc.
Planet. Space Sci. (GB), Vol. 1, No. 3, 161-72 (Aug., 1959).

As a result of a rocket-borne experiment performed in New Mexico on 18 March 1958 at sunset, data were obtained which led o conclusions concerning the concentrations of nitric oxide and nolecular oxygen in the altitude range 60 to 87 km. The technique used was that of absorption spectroscopy. A specially designed spectrograph, mounted in a biaxial pointing control, was flown in an Aerobee Rocket. Seven spectrograms were obtained. It was letermined that the concentration of nitric oxide in the altitude nterval 63 to 87 km cannot exceed 10^8 molecules/cm^3. The nolecular oxygen concentration in the same region was found to be essentially the same as derived from the assumption that the composition of the atmosphere below 90 km does not change with height. A comment is made concerning the solar continuum and solar Lyman-α radiation.

6587 CHARACTERISTICS OF THE RADIATION EMERGING FROM THE TOP OF A RAYLEIGH ATMOSPHERE.
. INTENSITY AND POLARIZATION. K.L.Coulson.
Planet. Space Sci. (GB), Vol. 1, No. 4, 265-76 (Sept., 1959).

Chandrasekhar's solution of the equation of radiative transfer in a medium scattering according to Rayleigh's law was used for an extensive series of computations of the scattered and diffusely reflected radiation directed outward from the top of a plane stratified model of the atmosphere. The results are discussed in two parts, the first of which deals with the intensity, degree of polarization, plane of polarization and the neutral points of the scattered and diffusely reflected radiation. The results are then compared with similar quantities for the diffusely scattered radiation from the sunlit sky.

6588 CHARACTERISTICS OF THE RADIATION EMERGING FROM THE TOP OF A RAYLEIGH ATMOSPHERE.
II. TOTAL UPWARD FLUX AND ALBEDO. K.L.Coulson.
Planet. Space Sci. (GB), Vol. 1, No, 4 277-84 (Sept., 1959).

For Pt I see preceding abstract. This second part is concerned with the upward flux obtained by an integration of the intensity over the entire hemisphere, for the incident radiation (a) being independent of wavelength or (b) having the spectral distribution of the extra-terrestrial solar radiation. Integration with respect to wavelength in the latter case, together with an approximation for the sphericity of the atmosphere, yields a value of 7.6% for the earth's planetary albedo due to scattering by the clear atmosphere. An approximation for ozone absorption decreases the computed albedo to 6.9%.

6589 DETERMINATION OF THE TRANSPARENCY COEFFICIENT OF THE ATMOSPHERE FROM THE POLARIZATION OF THE LIGHT OF THE SKY.
E.V.Pyaskovskaya-Fesenkova.
Dokl. Akad. Nauk SSSR, Vol. 134, No. 4, 812-15 (Oct. 1, 1960).
In Russian.

The sky brightness was measured (with or without a polaroid) using the author's visual photometer ["Investigations of the diffusion of light in the terrestrial atmosphere", Academy of Sciences, USSR, (1957)] at altitudes 1450 m, 500 m (Kazakhstan) and 200 m (Libyan desert). Solar radiation and the corona brightness were measured simultaneously in the same places by means of a corona photometer. Identical yellow Schott filters were used with both photometers. The degree of polarization P was determined from observations by measuring the brightness of a given point three times in succession, rotating the polaroid by 60° from one measurement to another. The transparency coefficients (p) were determined by three methods. For the angle of diffusion $\theta = 90°$ there exists a definite nonlinear relationship between P and p, independent of the place of observation, but there are no such relationships for $\theta = 60$ and 40°. Assuming $p = \exp(-\tau)$, where τ is the optical thickness of the atmosphere, one obtains linear relationships between P and $\log \tau$, the coefficients of correlation for $\theta = 90$, 60 and 40° being $r = -0.97 \pm 0.01$; -0.83 ± 0.05 and -0.63 ± 0.10. For $\theta = 90°$ the relationship is $\log \tau = 0.035 - 1.344\,P$. F.Lachman

6590 STUDY OF 1.4 μ, 1.9 μ, AND 6.3 μ WATER VAPOR BANDS AT HIGH ALTITUDES.
D.G.Murcray, F.H.Murcray, W.J.Williams and F.E.Leslie.
J. Opt. Soc.Amer., Vol. 51, No. 2, 186-95 (Feb., 1961).

On March 13, 1959, the infrared solar spectrum from 1 to 10μ was recorded at altitudes up to 90 000 ft by means of a balloon-borne spectrometer flown in conjunction with a biaxial pointing control. The amount of water vapour present at these altitudes was also measured by means of a frost-point hygrometer. Infrared absorptions depend not only on the amount of absorbing material traversed by the radiation but also on its pressure environment. Various methods have been advanced for predicting the absorption that would be suffered by radiation traversing a slant path in the atmosphere. Carpenter et al. have shown that the absorption should be equivalent to that suffered by radiation traversing a constant pressure path through an amount of absorbing gas given by

$$u_e = \int_{h_1}^{h_2} \frac{\alpha(h)}{\alpha_s}\,\rho(h)\,dh$$

Kinetic theory predicts that if temperature effects are neglected $\alpha = (P/P)\alpha_s$. The laboratory studies of Howard et al. indicate that for constant pressure paths and where k varies from band to band:

$$u_e = \int_{h_1}^{h_2}\left(\frac{P(h)}{P_s}\right)^k \rho(h)\,dh.$$

The absorptions were calculated for the 1.4 μ, 1.9 μ, and 6.3 μ bands using both expressions, the hygrometer data, and the laboratory data of Howard et al. Comparisons of the calculated and observed absorptions indicates that the latter expression gives better agreement with the observed values.

6591 LOW FREQUENCY ELECTROMAGNETIC RADIATION ASSOCIATED WITH MAGNETIC DISTURBANCES.

G.R.A.Ellis.
Planet. Space Sci. (GB), Vol. 1, No. 4, 253-8 (Sept., 1959).

Continuous observations of the amplitude and spectrum of naturally occurring radiation in the band 2-40 kc/s were made during the period June to December 1958 near Sydney, Australia. A large number of isolated noise bursts lasting for some hours were detected. The intensity ranged from 6×10^{-19} to 6×10^{-17} W m^{-2} (c/s)$^{-1}$ at 4.6 kc/s. Three main types of burst were identified and classified on a basis of their spectra which usually extended from 3 to 5 kc/s, 4 to 8 kc/s and 2 to 30 kc/s, respectively. Major bursts, which were always of the latter two types, were clearly associated with strong auroral and magnetic activity and some showed a reproducible sequence of amplitude variation lasting about 36 hours. On three occasions, a detailed correspondence between the intensity of the noise and of simultaneously occurring red oxygen airglow was observed. Theories of the origin of the noise are discussed.

6592 INITIAL RESULTS OF A NEW TECHNIQUE FOR INVESTIGATING SFERIC ACTIVITY.

G.Hefley, R.H.Doherty and R.F.Linfield.
J. Res. Nat. Bur. Stand.(USA), Vol. 65D, No. 2, 157-66 (March-April, 1961).

A technique for the measurement of spherics on a massive scale has been developed. The technique pertains largely to spectral and directional measurements. Representative samples of data are presented and discussed. The data samples include: (1) diurnal variations in spheric rates as a function of the 10.5, 40, and 100 kc/s component amplitudes; (2) spheric rates as a function of triggering level; (3) directional measurement of spheric rates; (4) correlation of directional spheric rates with weather reports; (5) spheric amplitude distributions at 10.5, 40, and 100 kc/s; and (6) comparison of the distribution of amplitudes of the spherics from two different storm areas. Recommendations for future measurements are made.

6593 THE RELATION BETWEEN LIGHTNING DISCHARGES AND WHISTLERS.

H.Norinder and E.Knudsen.
Planet. Space Sci. (GB), Vol. 1, No. 3, 173-83 (Aug., 1959).

A station for analysis of relations between lightning discharges and whistlers was operated near Uppsala. After preliminary tests in 1956-7 a definite programme was realized during the thunderstorm season of 1958. It was found that whistlers occur in groups — whistler situations — with periods often of $\frac{1}{2}$-$2\frac{1}{2}$ hr, exceptionally of 5-6 hr. Whistlers sometimes occurred in great numbers for shorter periods of time between total cessations. These extended over hours, days and even weeks. Whistler situations on days with thunderstorms were located by a c.r.o. direction finder. It was found that whilst a thunderstorm in one direction produced whistlers, a simultaneous thunderstorm in another direction at about the same distance sometimes did not. Investigation of variations in the same thunderstorm of the electric field force from atmospherics related to whistlers or not so related showed that atmospherics with the highest field force were always followed by whistlers. This was explained partially by facilitated propagation for wave-packets in the low-frequency band around 5 kc/s and partially by high initial energy in the discharges causing whistlers. A comparison in the same thunderstorm of waveforms from atmospherics not producing whistlers showed typically irregular variational forms and one single discharge in the lightning path. Waveforms of whistler-producing atmospherics showed regular variational forms with frequencies around 5 kc/s. In several cases the waveforms indicated multiple discharges in the lightning path.

MAGNETIC STORMS AND COSMIC RADIO NOISE ON 25 Mc/s AT AHMEDABAD (23°02' N; 72°38' E). See Abstr. 6653

6594 FREE-BALLOON BORNE METEOROLOGICAL REFRACTOMETER.

J.F.Theisen and E.E.Gossard
J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 149-54 (March-April, 1961).

A free-balloon-borne refractometer is described and sampl of soundings are shown. The instrument has been used for samp the refractive index through the troposphere in a study of the fin structure of refractive layers over Southern California. It uses fast-response temperature and humidity elements and is carried aloft by a standard radiosonde balloon. The instrument avoids t defects of the usual radiosonde for obtaining refractive index infi ation while allowing a nearly vertical sounding to be obtained wit out the disturbance of the atmosphere characteristic of a soundin taken by an aircraft.

6595 ABSORPTION, REFRACTION, AND SCINTILLATION MEASUREMENTS AT 4700 Mc/s WITH A TRAVELL WAVE TUBE RADIOMETER.

J.P.Castelli, J.Aarons, C.Ferioli and J.Casey.
Planet. Space Sci. (GB), Vol. 1, No. 1, 50-6 (Jan., 1959).

By means of radio astronomy techniques, measurements of atmospheric absorption, refraction, and scintillation were made C band (4700 Mc/s), with the sun as a source of radiofrequency energy. The equipment, a comparison-type radiometer, used travelling-wave tubes, a tuned radio frequency receiver, and an altazimuth antenna mount. The average solar temperatures recorded for the period varied from 22 000°K at zero elevation t 26 000°K at 60° of elevation. Individual readings ranged between 18 000°K and 30 000°K. The mean absorption, based on average solar temperatures at the various elevations for the period, was 0.00348 dB/km. Refractive errors were approximately the same as optical although deviations from the mean during any day were large. Atmospheric scintillation f periods ranging from 0.5 sec to 90 sec were recorded. Scintillat amplitudes ranged from 2% to 20% of antenna signal temperature low angles. At high elevation angles, scintillations rarely reach 10% and were generally less than 1%.

6596 APPEARANCE OF A SPRING MAXIMUM IN NUCLE TEST DEBRIS IN 1960.

P.F.Gustafson, S.S.Brar and M.A.Kerrigan.
Science (USA), Vol. 133, 460-1 (Feb. 17, 1961).

The existence of a spring maximum in fallout deposition due the disruption of the tropopause in middle latitudes has been deba for the past several years. Evidence obtained from air filters indicates elevated levels of radioactivity from nuclear test in surface air during April through July 1960.

6597 TUNGSTEN-185 FROM NUCLEAR BOMB TESTS AS TRACER FOR STRATOSPHERIC METEOROLOGY.

H.W.Feely and J.Spar.
Nature (GB), Vol. 188, 1062-4 (Dec. 24, 1960).

In the "Hardtack" tests between May and July, 1958, about 95 of W^{185}, as well as other radionuclides, were injected into the stra sphere above the Bikini—Eniwetok area. Vertical profiles in mer dional planes of the tungsten and Sr^{90} concentrations were constru from the samples of stratospheric dust. These profiles for the period Nov.-Dec., 1959 show a maximum of tungsten activity arou 70 000 ft over the equatorial zone, and a region of greatest concentration with height decreasing steadily towards the poles. This di bution is likely to have been produced by lateral turbulent mixing together with a systematic sinking of the radioactive debris as it mixed polewards, rather than by an organized meridional circulat north and south from the equatorial zone at the same level and a sinking into the lower stratosphere over the poles. J.M.Sta

LONG-DISTANCE SOUND PROPAGATION WAVEGUIDE THEORY. See Abstr. 4405

UPPER ATMOSPHERE IONOSPHERE

(See also Space Research. Abstracts on radiowave propagation in ionized media will also be found under Electromagnetic Waves)

6598 POLAR, MAGNETIC, AURORAL, AND IONOSPHERIC PHENOMENA. E.H.Vestine.

v. mod. Phys. (USA), Vol. 32, No. 4, 1020-5 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). e earth as a magnetic mirror machine is described. There appear in- ase electric currents flowing within the electrically conducting nosphere. These currents are strongest at the auroral zones. The eory of mirror machines is applied to geophysical problems. It is own that adiabatic invariants of auroral particle motion can very ccessfully delineate the average auroral isochasms. It also appears at the time sequences of auroral morphology and the duration of rious auroral forms are likely to be explicable on the basis of bility considerations of plasma physics.

6599 THE UPPER ATMOSPHERE AND OUTER SPACE. I. DENSITIES, TEMPERATURES AND CONCENTRA- ONS OF ATMOSPHERIC CONSTITUENTS FROM 130 TO 1000 KM.

B.Mathur and A.P.Mitra.

sci. industr. Res. (India), Vol. 19A, No. 7, 311-17 (July, 1960).

On the basis of the values of atmospheric densities that have cently been inferred both in the U.S.A. and in the U.S.S.R. from servations of satellite drag, a self-consistent atmospheric model developed over the height range 130-1000 km. The data are found be consistent with scale height, increasing with an approximate adient of 0·166 up to about 650 km, and remaining constant above is height. Atmospheric density is found to be considerably larger an that in the Rocket Panel model, but is close to the model given rlier by S.K. Mitra [The Upper Atmosphere. Calcutta: Asiatic ciety (1952)]. The concentration of atomic oxygen, which forms e bulk of the total particle concentration at a height of 1000 km, is high as 4×10^5 cm^{-3}. The atmospheric temperature rises from value of 462°K at 130 km to a value of about 2000°K at 600 km and mains 2000°K above this height. The mean molecular mass drops om a value of 22·6 at 130 km to its minimum value of 16·0 at 450 km.

6600 ENERGY SOURCES OF THE UPPER ATMOSPHERE. V.I.Krassovsky

anet. Space Sci. (GB), Vol. 1, No. 1, 14-18 (Jan., 1959).

Investigations by earth satellites indicate that the product of mospheric density and the square root of scale height at the 0-230 km altitude is higher in daytime than at night and also gher in polar regions than in equatorial ones. Interpretation of ese data indicates that density and temperature in this region are uch higher than previously supposed. Various energy sources hich may account for this variable heating and swelling of the mosphere are considered. An explanation is given in terms of riable heating due to electric currents in the upper atmosphere duced by magnetic fields frozen in the corpuscular streams. It supposed that this mechanism can accelerate atmospheric ions d electrons.

6601 AN INTERIM ATMOSPHERE DERIVED FROM ROCKET AND SATELLITE DATA. I.Harris and R.Jastrow.

anet.Space Sci. (GB), Vol. 1, No. 1, 20-6 (Jan., 1959).

The analysis of radio tracking data obtained from the U.S. and S.S.R. satellites provides information on the density and tempera- re of the atmosphere at high altitudes. The combining of this in- rmation with data recently obtained from rocket flights at altitudes low 200 km, permissible construction of a model atmosphere which elds a relatively unambiguous determination of denstty up to 400 km. ove 200 km this atmosphere indicates values of temperature and nsity which are substantially greater than those predicted in re- nt extrapolations to these altitudes. The proposed atmosphere is sed on rocket data obtained at latitude 33° N, together with orbit ta from satellite 1957 α2, whose perigee was located at 39° N during e period of observation. The model therefore describes atmos- eric conditions at temperate latitudes. Additional data on the den- y of the equatorial belt between 33° N and 33° S are available from the U.S. satellites, 1958 α (Explorer I) and 1958 β (Vanguard I). The results of preliminary analysis on these satellites is given. Unfortunately they cannot be combined with the rocket data and the results from 1957 α2, because of the pronounced latitude dependence of density above 200 km.

6602 DERIVATION AND ANALYSIS OF ATMOSPHERIC DENSITY FROM OBSERVATIONS OF SATELLITE 1958 EPSILON. G.F.Schilling and C.A.Whitney.

Planet. Space Sci. (GB), Vol. 1, No. 2, 136-45 (April, 1959).

The orbital behaviour of satellite 1958 epsilon was analysed to derive average upper atmosphere densities in the altitude interval of 257-270 km between latitudes 50° N and 50° S. The method of computation and possible errors in the calculations are discussed in detail. At an altitude of 262.5 km above intermediate northern latitudes, the most probable value of mean density was found to be $1.3 \pm 0.4 \times 10^{-13}$ g/cm^3. All numerical results showed a high degree of internal consistency, but gave no evidence of any appreciable variation of average density between latitudes 49° N and S during the time interval July to November, 1958. The data did not warrant film interpretation of small deviations which could be ascribed to either a day—night effect or slightly higher mean densities in the northern hemisphere. At about 50° N and S latitudes, however, a sharp discontinuity was found, with the average density value in the northern hemisphere about twice that in the southern hemisphere. Assuming this to be a real phenomenon, the authors present tentative conclusions about the physical and dynamical state of the upper atmosphere. In addition, an explanation is offered for some of the apparent discrepancies between mean density values obtained from satellite observations and many of the measurements by means of high-altitude research rockets.

6603 ATMOSPHERIC DENSITIES FROM SATELLITES AND ROCKET OBSERVATION.

K.W.Champion and R.A.Minzner.

Planet. Space Sci. (GB), Vol.1, No. 4, 259-64 (Sept., 1959).

Atmospheric densities deduced from high altitude rocket flights have a large variability of which a large percentage is undoubtedly due to measurement errors. Prior to the I.G.Y. the available density data gave reasonable support to the A.R.D.C. Model Atmosphere. Satellite data which at first appeared to be inconsistent with rocket data are now seen to be continuous with the average of presently available rocket derived densities. The current data suggest the revision of the 1956 A.R.D.C. Model to lower densities near 100 km altitude and demand higher densities above 160 km (a twenty fold increase at 500 km). The revised altitude distribution of density implies (1) lower temperatures at 90 km and (2) temperature—altitude gradients between 105 and 160 km (two times the molecular-scale-temperature gradient of the 1956 A.R.D.C. Model). Density—altitude and temperature—altitude profiles for a revised model atmosphere are discussed.

6604 REGULAR MOTIONS IN THE IONOSPHERE: ELECTRIC AND MAGNETIC RELATIONSHIPS. S.Chapman.

Bull. Amer. Meteorol. Soc., Vol. 42, No. 2, 85-100 (Feb., 1961).

Regular worldwide motions in the ionosphere produce daily varying currents there by dynamo action in association with the geomagnetic field. The changing field of these currents induces electric currents within the earth. At the earth's surface, the combined magnetic field of these currents is measured. The parts of primary and secondary origin can be determined separately. The form and intensity of the ionospheric currents can be found. Their height is inferred from the study of the ionospheric electron density and conductivity; it can also be measured by rockets. The daily varying airflow in the layer bearing the electric current, at heights from about 90 to 125 km, can to some extent be inferred. The motion is due partly to the sun's thermal and tidal action and partly to the moon's tidal action. Many aspects of the magnetic variations and the inferred ionospheric motions are considered in some detail, especially their seasonal and sunspot-cycle changes and their variations from day to day.

6605 A STUDY OF WINDS BETWEEN 80 AND 100 km IN MEDIUM LATITUDES. W.G.Elford.

Planet. Space Sci. (GB), Vol. 1, No. 2, 94-101 (April, 1959).

Results of a systematic investigation of winds in the upper atmosphere by the radio observation of drifting meteor trails are described. It is shown that in medium latiudes the diurnal behaviour of the winds in this region can be described in terms of three horizontal components of comparable magnitude; a prevailing component and two oscillatory components with periods of 24 and 12 hr. The prevailing winds are predominantly zonal and are directed toward the East during most of the year. Large wind gradients are present in summer and winter. In general the periodic components represent anticlockwise rotation of the wind vectors. The seasonal variations in the magnitude and phase of the 24-hr oscillation suggest a direct thermal origin for this component. The amplitude and phase of the 12-hr component vary in a complex manner throughout the year, but the mean amplitude increases with height.

6606 IONOSPHERIC DISTURBANCE AT THE TIME OF COSMIC RAY INCREASES. C.Collins and D.H.Jelly.
Nature (GB), Vol. 189, 128-9 (Jan. 14, 1961).

Ionospheric data for three Canadian stations have been examined for the period centred on the two reported increases in total cosmic-ray intensity in 1957 (viz. on Jan. 21 and Dec. 4). No unusual conditions were apparent for the December increase. In January the situation was complex: details are given of possible associations with a geomagnetic storm and a polar-cap absorption event. G.M.Brown

SCALE TIMES AND LENGTHS IN IONOSPHERE.
See Abstr. 5185

6607 STATISTICS OF A RADIO WAVE DIFFRACTED BY A RANDOM IONOSPHERE. S.A.Bowhill.
J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 3, 275-92 (May-June, 1961).

For some purposes, particularly in connection with the study of the random structure of the lower ionosphere, using very low frequencies, it is necessary to find the detailed statistical properties of a random signal diffracting in free space. Mathematical tools for evaluating these parameters have been developed, and are applied in this paper. Allowance is made for the effect of sphericity of the wave incident on the ionosphere, and anisotropy of the irregular variations of signal is permitted. The case of oblique incidence of a wave on the ionosphere is also considered.

REFRACTIVE INDEX FOR E.M. WAVES IN DRIFTING PLASMA.
See Abstr. 5599

ABSORPTION OF RADIO WAVES IN RESONANCE REGIONS OF NON-HOMOGENEOUS PLASMA. See Abstr. 5600

6608 ARTIFICIAL ELECTRON CLOUDS. I. SUMMARY REPORT ON THE CREATION OF ARTIFICIAL ELECTRON CLOUDS IN THE UPPER ATMOSPHERE.
F.F.Marmo, L.M.Aschenbrand and J.Pressman.
Planet. Space Sci. (GB), Vol. 1, No. 3, 227-37 (Aug., 1959).

A systematic study has been initiated for the purpose of better understanding the problems associated with the creation of artificial electron clouds in the upper atmosphere. A series of eight rocket experiments has been performed whereby artificial electron clouds were produced between 70 km and 130 km. The ground-based detection networks that were employed are discussed, and included is a method of correlating both optical and radio-radar data. This affords a new dimension for propagation and upper atmospheric studies. This paper, the first of a series, is devoted to summarizing the overall concepts, methods and techniques, and operating procedures employed in this study. It includes tabulated summaries of the various optical and radio-radar detection data in addition to some scientific uses of artificial electron clouds.

6609 ARTIFICIAL ELECTRON CLOUDS. II. GENERAL CONSIDERATIONS.
F.F.Marmo, J.Pressman and L.M.Aschenbrand.
Planet. Space Sci. (GB), Vol. 1, No. 4, 291-305 (Sept., 1959).

A square-well model is used to describe the distribution of contaminant ejected into the upper atmosphere immediately after the fast initial expansion. The diffusion equation is applied to this model and the salient features are noted. Basic equations are applied to this simplified model to describe the electron generative and decay processes on a term-by-term basis, in order to ascertain the relaxation times involved for the several interrelated problems. Chemical consumption of the alkali metal contaminant by reaction with the ambient species is found to be negligible above 95 km. It is concluded that for generation methods similar to those outlined here the practical altitude limits of generation of long lived electron clouds is between about 70 and 200 km; chemical consumption determines the lower while the diffusion process establishes the upper limit.

6610 ARTIFICIAL ELECTRON CLOUDS. III. RELEASE ATOMIC POTASSIUM AT 121 km.
F.F.Marmo, L.M.Aschenbrand and J.Pressman.
Planet. Space Sci. (GB), Vol. 1, No. 4, 306-18 (Sept., 1959).

Reports the results of the first successful rocket seeding e ment expressly designed for the generation of an optimum type artificial electron cloud. The analysis and interpretation of the was successfully accomplished by assigning the initial ionizati thermal effects after which solar photoionization of the release contaminant predominates. This was achieved by the daytime Aerobee release of atomic potassium at an altitude of 121 km. best fit of experimental data was dependent on varying sensitivi and extent of several parameters. These include D_e, the effect diffusion coefficient; c, the thermal ionization efficiency; r_o, the initial half width of the electron cloud and the chemical yield. Approximate values for these are deduced. C-3 ionosonde data the change in cloud slant range with time was utilized to obtain measure of the horizontal wind velocity at about 121 km; this va is about 78 m/sec. Extrapolation of the obtained information w employed in order to ascertain the feasibility of utilizing other rocket carriers for experiments of this kind. This also afforde opportunity to deduce the order of magnitude results which shou have been obtained by the release of caesium from an Aerobee, experiment attempted earlier by the authors which mechanicall failed. The interesting results also serve to suggest several ne rocket experiments.

6611 ARTIFICIAL ELECTRON CLOUDS. IV. THERMAL IONIZATION STUDY, NIGHT TIME CESIUM RELEASE AT 101 km.
J.Pressman, F.F.Marmo and L.M.Aschenbrand.
Planet. Space Sci. (GB), Vol. 2, No. 1, 17-25 (Oct., 1959).

Reports radio-radar and optical observations of an electron c created by the night time release of caesium at 101 km from a Nike Cajun rocket on 20 May 1958. An analysis of the electron yield base the thermochemistry and the Saha relationship indicates that the electrons observed can be reasonably ascribed to thermal ioniz

6612 ARTIFICIAL ELECTRON CLOUDS. V. MORNING TWILIGHT STUDY, RELEASE OF CESIUM AND SODIUM AT 128 AND 116 km.
F.F.Marmo, J.Pressman, E.R.Manring and L.Aschenbrand.
Planet. Space Sci. (GB), Vol. 2, No. 2-3, 174-86 (April, 1960).

Reports the results and analysis of two rocket experiments designed to study the simultaneous optical and radio-radar behaviour of artificial electron clouds. The optical properties w obtained by "doping" the cloud with a small percentage of sodiu one experiment and using a complete payload of sodium in anoth These experiments were performed with the Nike-Cajun under morning twilight conditions on 21 and 22 May 1958 respectively. Analyses are made of radar slant range behaviour with time, optical growth rate and variation of critical frequency with time In the last, a more advanced analysis is used which allows for the differential diffusion of charged and neutral particles. The results from these analyses are compared to the estimated atmospheric properties and to thermo-chemical release propert These are also cross-checked among themsevles. This study indicates the utility of combined radio-radar and optical observa Values are derived for the following parameters: the neutral and ambipolar diffusion coefficients, chemical yield, thermal ionization efficiency, wind velocity and wind shear.

6613 INCOHERENT SCATTERING BY FREE ELECTRONS AS A TECHNIQUE FOR STUDYING THE IONOSPHER AND EXOSPHERE: SOME OBSERVATIONS AND THEORETICAL CONSIDERATIONS. K.L.Bowles.
J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 1, 1-14 (Jan.-Feb., 1961).

A suggested technique for measuring the electron density pr both below and above the F region maximum. Observations are reported which confirm the existence of the incoherent scatter an show that its intensity is essentially the predicted value. The observed Doppler broadening is considerably smaller than origin predicted. An explanation for the reduced Doppler broadening is offered. The scatter is explained as arising from statistical fluctuations of electron density, the distributions of which is controlled by the positive ions.

6614 AN EXAMPLE OF HEAVY ABSORPTION IN THE V.H.F.-BAND IN THE ARCTIC IONOSPHERE.

L.Harang and J.Tröim.

Planet. Space Sci. (GB), Vol. 1, No. 2, 102-4 (April, 1959).

From records of meteor echoes on 40 Mc/s and of scintillations from the Cassiopeia source on 45 Mc/s it is shown that on 7 July 1958 in the early morning hours a very heavy absorption appeared. The meteor echoes disappeared completely and the radiation from Cassiopeia diminished to less than 1/5 of its normal value. The observations were made at Tromsö ($\phi = 70^\circ$N) and in the direction towards the auroral zone. A great geomagnetic storm appeared with a sudden commencement at 08.40 M.E.T., about 5 hr after the absorption effect of the ionosphere had started.

6615 STRONGLY ABSORBING LAYERS BELOW 50 km.

B.Hultqvist and J.Ortner.

Planet Space Sci. (GB), Vol. 1, No. 3, 193-204 (Aug., 1959).

In a few cases of very strong absorption of very long duration observed at Kiruna Geophysical Observatory during the summer of 1958, the height of the upper boundary of the ionized layer has been found to be about 50 km. It is shown that this height value accords well with what is to be expected if the ionizing agent consists of protons. Earlier proposed interpretation is discussed with regard to this new height information.

6616 RADIO WAVE PROPAGATION CHARACTERISTICS OF A SIMPLE IONOSPHERIC MODEL BASED ON ROCKET DATA.

L.Zhekulin.

Planet. Space Sci. (GB), Vol. 2, No. 2-3, 110-20 (April, 1960).

Valuable experimental data have been obtained with the help of rockets, relating to investigations of distribution of ionization with altitude in high atmospheric regions. The available results make it possible to attain a more specific understanding of ionosphere structure and lead to a number of conclusions pertaining to the problem of radiowave propagation at high altitudes.

6617 SOME STUDIES ON SPORADIC E.

P.Venkateswarlu and R.Satyanarayana.

J. sci. industr. Res. (India), Vol. 20B, No. 1, 8-10 (Jan., 1961).

Results of studies of sporadic E ionization made during Sept., 1959 to Jan., 1960 at Tirupati are presented. The monthly mean maximum fE_s was found to occur around noon. The abnormally high values of fE_s observed on certain occasions are explained as due to thunderstorm activity.

6618 ON SOME CHARACTERISTICS OF THE E_s-LAYER.

M.Bossolasco and A.Elena.

Planet. Space Sci. (GB), Vol. 1, No. 3, 205-12 (Aug., 1959).

Some aspects of the dependence of the E_s-ionization on the geomagnetic field are derived; further, an attempt is made to deduce the mean world-wide drift direction of E_s in summer, using the time displacement that occurs for the daily maxima of the hourly median values of f_oE_s.

6619 GEOMAGNETIC AND CURRENT CONTROL OF E-REGION ABSORPTION.

J.E.Shaw.

Planet. Space Sci. (GB), Vol. 2, No. 1, 1-9 (Oct., 1959).

Seasonal variations of ionospheric absorption were studied from the mid-day routine tabulations of the parameter f_{min}, from eighteen ionospheric stations. A quantity, $B = f_{min} : f_oE$, is defined and its variations in both geographic and geomagnetic latitudes are studied. It is shown that the value of B varies about a steady value, the amplitude and sense of the variation being related to the intensity of the current in the S_q current system and the latitude of the station. A lunar semi-diurnal variation in the quantitiy B is found for Kihei. The ratio of the solar and lunar variations in B is found to compare favourably with the ratio of the total currents in the Sq and lunar current systems. A recent model of the E-layer is used to define the upper and lower limits of the absorbing region, and it is concluded that the absorbing region occupies the whole of the dynamo-current region below the reflection height of the exploring waves. The control of the absorption process is related to the vertical drift of neutral ionization resulting from east-west current flow. A mechanism is proposed in which the scale size of scattering irregularities in the E-layer is changed by the direction and velocity of the vertical drift of ionization. A number of observed absorption effects is discussed and it is shown that the theory describes the qualitative behaviour observed in these effects. Reference is made to the likely importance of the process of control of absorption in the auroral zones.

6620 A THEORY OF THE ORIGIN AND GEOMAGNETIC CONTROL OF TWO TYPES OF HIGH LATITUDE E_s.

J.E.Shaw.

Planet. Space Sci. (GB), Vol. 2, No. 1, 56-9 (Oct., 1959).

Observations of night-time E_s occurrence from four stations near the southern auroral zone are analysed. A major peak in the diurnal curves for the percentage hourly occurrence of f type E_s is identified with the peak of occurrence of Auroral Belt type E_s discussed by Penndorf and Coroniti for the northern auroral zone. It is found that the probable low latitude extent of this peak is approximately 50° geomagnetic. A theory is proposed which attributes the occurrence of Auroral Belt type E_s and Thule type E_s to two separate processes, both of which involve the entry of electrons into the ionosphere under the control of the geomagnetic field. The theory shows that Auroral Belt type E_s may be caused by electrons from a region of trapped particles the extent of which can be defined by the extent in geomagnetic latitude of the night-time peak in f type E_s occurrence. Thule type E_s may be caused by an influx of electrons into the ionosphere from a stream of particles approaching from the direction of the sun. The deflections of the peak of occurrence of f type E_s from the midnight magnetic meridian, and of the Thule type E_s from the "geomagnetic noon" meridian, are a function of the mean energy of the electrons and the curvature and intensity of the lines of force in the geomagnetic field.

OUTLINE OF A THEORY OF MAGNETIC SEPARATION OF AURORAL PARTICLES AND THE ORIGIN OF THE S_D FIELD.
See Abstr. 6636

6621 OBSERVATION OF F-LAYER AND SPORADIC-E SCATTER AT V.H.F. IN THE FAR EAST.

K.Miya, T.Sasaki and M.Ishikawa.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 1, 93-9 (Jan.-Feb., 1961).

Describes properties of sporadic-E scatter and F-layer scatter observed over the Okinawa-to-Tokyo path (1480 km) and the Philippines-to-Tokyo path (2850 km), operating at frequencies of about 50 Mc/s. Sporadic-E scatter is often observed on the Okinawa signal in the evening hours and has the closest correlation (0.94 in correlation ratio) with the occurrence of sporadic E characterized by the descriptive symbol M of all ionospheric factors. The bearing of the sporadic E scatter shows a regular diurnal variation similar to that of the normal E-layer scatter. F-layer scatter generally appears on the Philippine signal in autumn when the F-layer at the path midpoint displays an anomaly denoted by the symbol R or S, having a top frequency of higher than 14 Mc/s. A pulse test exhibited a pattern of multipath signals extending over more than 1 msec. The bearing of the F-layer scatter, an evening phenomenon, gradually deviates westwards from the great-circle path with the lapse of time.

6622 IONOSPHERIC MOTIONS OBSERVED WITH HIGH FREQUENCY BACKSCATTER SOUNDERS.

L.H.Tveten.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 115-27 (March-April, 1961).

Techniques for determining the characteristics of movements of irregularities in the F2-region by the use of backscatter records are described. The results of an analysis of backscatter data obtained during December 1952, at Sterling, Virginia, at a frequency of about 13.7 Mc/s are presented and found to be in good agreement with those of other investigators.

6623 BIFURCATION AND OTHER IRREGULARITIES OF THE IONOSPHERIC F2-LAYER.

E.Woyk (Chvojková).

Nature (GB), Vol. 188, 906-7 (Dec. 10, 1960).

Details are given of the author's theory of photoionization in the F layer. Bifurcation is attributed to the development of a secondary minimum of electron density at the level of maximum electron production as a result of transformation into heat of the excess energy of the ionizing radiation over that required to effect the ionization. The diurnal and seasonal variation of f_oF2, and its unexpected dependence on solar activity, can also be explained by this theory. G.M.Brown

6624 EFFECTS OF DIFFUSION OF ELECTRONS NEAR THE MAGNETIC EQUATOR.

V.C.A.Ferraro, J.E.C.Gliddon and P.C.Kendall.

Nature (GB), Vol. 188, 1017-18 (Dec. 17, 1960).

The authors discuss the latitude variation of electron density in a model F2 layer which takes account of production, loss and vertical diffusion of ionization. Their curves show a flat maximum at the magnetic equator, contrary to the conclusion of Schmerling (Abstr. 1531 of 1961) that vertical diffusion could give rise to a minimum of electron density at the equator; reasons for this discrepancy are discussed. They conclude that the equatorial anomaly of F2 layer electron density is caused by processes not included in their model, such as horizontal diffusion. H.Rishbeth

6625 ABSORPTION AND ELECTRON DISTRIBUTION IN THE F_2 LAYER DETERMINED FROM MEASUREMENTS OF TRANSMITTED RADIO SIGNALS FROM EARTH SATELLITES.

A.N.Kazantsev.

Planet. Space Sci. (GB), Vol. 1, No. 2, 130-5 (April, 1959).

Comparison is made between measured field strengths of transmitted signals from earth satellites and those theoretically predicted when the transmitter position is in the region of maximum electron concentration of the F_2 layer, below it, and above it. The observed absorption value agrees best for a biparabolic distribution with exponential continuation with $k = 8 \times 10^{-3}$ where the electron concentration is given by $N = N_0e^{-kh}$. The number of electrons per column in the upper region of the F_2 layer is deduced to be 1.5×10^{13} electrons/cm^2. This value is compared to the findings of Burgess. Curves are given of field strengths at distances greater than 10 000 km. At distances of 16 000 km the formation of ionospheric wave guides make possible the transmission of radio signals.

6626 ON METEOR ABLATION IN THE ATMOSPHERE.

F.Verniani.

Nuovo Cimento (Italy), Vol. 19, No. 3, 415-42 (Feb. 1, 1961).

The usually adopted theory of the meteoric ablation is critically examined and improved. More approximate expressions are given for the fundamental equations of the ablation, particularly useful for low velocity meteors. New methods are proposed for determining the effective latent heat of ablation and the meteoric density.

6627 SOME REMARKS ON THE NATURE AND ORIGIN OF NOCTILUCENT CLOUD PARTICLES.

D.Deirmendjian and E.H.Vestine.

Planet. Space Sci. (GB), Vol. 1, No. 2, 146-53 (April, 1959).

Continuous spectra of the light from noctilucent clouds, recently obtained near Moscow by Grishin, are analysed after accounting for the selective attenuation of the lower atmosphere and the spectrum of sunlight. It is found that the spectra may be explained in terms of primary scattering of direct sunlight by dielectric spheres with a maximum radius of 0.4 μ, and certain night sky emissions. The apparent absence of any nocturnal ozone layers above 35 km is also noted. The possibility of an ice composition of the clouds formed by condensation of terrestrial water vapour is examined and found unjustified on physical grounds. Rather a silicaceous or similar composition and an interplanetary origin for the cloud particles is favoured and a close relation with the Martian "blue haze" is suggested.

6628 THE ORIGIN OF NITROGEN IONIZATION IN THE UPPER ATMOSPHERE.

J.W.Chamberlain and C.Sagan.

Planet. Space Sci. (GB), Vol. 2, No. 2-3, 157-64 (April, 1960).

Although the N_2^+ First Negative bands in twilight are probably the result of resonance scattering by N_2^+ ions, the symmetry of morning and evening observations make it unlikely that the ionization is produced by sunlight in the E-region. If the flux in the He II λ304 line is as high as 15 erg cm^{-2} sec^{-1}, the observed First Negative system intensities can be accounted for, and the nitrogen ionization is localized in the F-region. If the flux in the λ304 line is much smaller, the ionization must be produced by incident charged particles in the E-region.

6629 FAR ULTRAVIOLET RADIATION IN THE NIGHT SKY.

J.E.Kupperian, Jr, E.T.Byram, T.A.Chubb and H.Friedman.

Planet. Space Sci. (GB), Vol. 1, No. 1, 3-6 (Jan., 1959).

Rocket measurements have shown that the night sky is aglow with a diffuse Lyman-α (1216 A) emission amounting to 10^{-2} erg cm^{-2} sec^{-1} from the entire hemisphere. The glow was so bright that celestial sources of Lyman-α could not be detected through it. At wavelengths near 1300 A discrete celestial sources were observed, which contributed 10^{-4} erg cm^{-2} sec^{-1} from the entire sky in the wavelength interval 1225-1350 A.

6630 ON HYDROGEN EMISSION IN THE NIGHT GLOW.

I.S.Shklovsky.

Planet. Space Sci. (GB), Vol. 1, No. 1, 63-5 (Jan., 1959).

H_α emission was observed at the Zvenigorod Station of the Institute for Atmospheric Physics. The width of the observed emission does not exceed the instrumental width of 2 A. It is sh that the recombination of protons and electrons cannot account f this emission, and that a probable source is the resonance scattering of solar L_α radiation by interplanetary neutral hydrog atoms. The possibility that L_α radiation arises from a "geocor is considered as is the effect of resonance scattering of L_β radiation and the intensity at H_α resulting from fluorescence wh L_α and L_β are absorbed.

6631 RELATIONSHIP BETWEEN RED AURORAL ARCS A IONOSPHERIC RECOMBINATION.

G.A.M.King and F.E.Roach.

J. Res. Nat. Bur. Stand. (USA), Vol. 65D, No. 2, 129-35 (March-April, 1961).

A "monochromatic" (6300 A) auroral arc, observed photometrically to be north of Boulder, Colo., was identified with oblique echoes on ionograms taken near Boulder. The auroral emission is explained in terms of a great enhancement of ionospheric recombination. The recombination process is shown to depend on the density of molecular nitrogen in the ionospheric F-region; the change in nitrogen density during and after aurora activity, responsible for the change in recombination rate, is ascribed to the combined effects of heating and mixing of the atmosphere at the lower ionospheric heights.

6632 RADAR ECHOES FROM THE AURORA AT 1300 Mc/s

E.Eastwood, G.A.Isted and J.D.Bell.

Nature (GB), Vol. 189, 115-17 (Jan. 14, 1961).

Three outstanding magnetic disturbances occurred in 1959 a 1960, and on each occasion auroral echoes were recorded on a ra operating on the high frequency of 1300 Mc/s at Great Baddow, England. The mean height of the auroral layer (90 km) is lower than that suggested by work at much lower frequencies, and it seems likely that the rare extreme solar outbursts which cause such violent disturbances of the ionosphere yield more energetic particles capable of ionizing at lower levels and of giving aurora at lower latitudes. G.M.Bro

6633 A "SKY LENS" FOR AN AURORAL SPECTROGRAPH.

N.J.Rumsey.

Optica Acta (Internat.), Vol. 8, No. 1, 17-19 (Jan., 1961).

A "sky lens" images a strip of sky on the entrance slit of a spectrograph. Then the intensity distribution of each spectral emission from the strip of sky is mapped along the corresponding spectral line. In order to reduce light losses to a minimum a sing lens component may be used for this purpose (in place of the usua two components), but one surface should be aspherized. If this su face is made an hyperboloid the lens performs very well over a 2 field.

6634 RAPID-RESPONSE ELECTROPHOTOMETER FOR MEASURING THE INTENSITY OF THE AURORA BOREALIS.

I.G.Frishman.

Pribory i Tekh. Eksper. (USSR), 1958, No. 1, 128-30 (Jan.-Feb.). In Russian.

The apparatus allows the measurement of up to 10 spectral bands per second and the result is displayed on a ribbon oscillogra [English translation in: Instrum. exper. Tech. (USA), No. 1, 143-4 (Jan.-Feb., 1958; publ. April, 1959)].

6635 INTERPLANETARY MAGNETIC FIELD AND THE AURORAL ZONES.

J.W.Dungey.

Phys. Rev. Letters (USA), Vol. 6, No. 2, 47-8 (Jan. 15, 1961).

The equipotentials in the ionosphere resulting from a movement of interplanetary plasma southward in the ecliptic plane are shown to resemble the well-known S_D current system, when the influence of the interplanetary magnetic field is taken into account. The sudden reversal of currents at the auroral zone is linked with the occurrence of neutral points in the combination of the interplan tary and geomagnetic fields. G.M.Brow

6636 OUTLINE OF A THEORY OF MAGNETIC SEPARATION OF AURORAL PARTICLES AND THE ORIGIN OF THE S_D FIELD. J.E.Shaw.

Planet. Space Sci. (GB), Vol. 2, No. 1, 49-55 (Oct., 1959).

The diurnal variations of occurrence of two types of sporadic E-ionization at Macquarie Island (geomagnetic latitude 61.1°S) are identified with the diurnal variations of the flux of incoming protons and electrons. It is shown that protons and electrons which have been accelerated under the control of the geomagnetic field, will be separated by magnetic forces resulting from their motion along the curved geomagnetic lines of force. The resulting pattern of precipitation in the atmosphere explains qualitatively the regular diurnal features of the occurrence of sporadic E-ionization. An extension of the theory provides a basis for interpretation of the observed development of a visual auroral display, with particular reference to the mode of formation of visual auroral forms. The theory explains the origin of the field responsible for the S_D magnetic variations and is in agreement with the spiral occurrence of magnetic disturbance variations observed in the north polar regions by Meek (see Abstr. 10120 of 1955).

6637 HYDROGEN EMISSION AND TWO TYPES OF AURORAL SPECTRA. G.I.Galperin.

Planet. Space Sci. (GB), Vol. 1, No. 1, 57-62 (Jan., 1959).

Various characteristics of auroral activity were correlated with the hydrogen emission. This emission was studied with the CΠ-48 and CΠ-47 spectrographs having dispersions of 85-95 and 200 A/mm respectively. The observations were made at the Loparskaya station of the Institute for Atmospheric Physics, U.S.S.R. where the geomagnetic latitude is 64°. The correlations include the intensity of H_α with: (1) K-index. (2) The atomic lines of OI, OII, NI, and NII. (3) The molecular bands 1 NG and 2 NG of N_2^+ and 1 NG of O_2^+. (4) The intensities of H_β and H_γ as well as their profiles. (5) Radio reflections.

6638 POLARIZATION OF THE RED OXYGEN AURORAL LINE. R.A.Duncan.

Planet. Space Sci. (GB), Vol. 1, No. 12, 112-14 (April, 1959).

During an aurora on 8 July 1958 the zenith 6300 A oxygen emission was found to be about 30% plane polarized with the magnetic vector North-South. It is shown that such polarization would be expected if the aurora was excited by electrons whose predominant motion was gyration about the geomagnetic field lines.

6639 EXCITATION OF O_2 ATMOSPHERIC BANDS IN THE AURORA. L.Wallace and J.W.Chamberlain.

Planet. Space Sci. (GB), Vol. 2, No. 1, 60-70 (Oct., 1959).

Spectra of the aurora show a wide disparity between the rotational temperatures of the two observed atmospheric bands, $b\ {}^1\Sigma_g^+ \rightarrow X\ {}^3\Sigma_g^-$, with Trot(0-1) ≅ 200°K and Trot(1-1) > 700°K. As the rotational structure of the bands is not resolved, it is not absolutely certain that the temperature anomaly is real, but known features in the auroral spectrum would not produce the effect through blending. Fluorescence in the 0-0 band provides a possible but improbable explanation. Another alternative to explain the data is excitation of O_2 by energy transfer from $O(^1D)$ (upper term of the red lines) followed by vibrational deactivation. In the latter case, the relative intensities of the O_2 bands and the [OI] red lines gives an indication of the rate coefficients for the relevant reactions, which are then used to predict the deactivation probability for $O(^1D)$ as a function of height. The reactions discussed give a satisfactory explanation of the absence in the airglow of atmospheric O_2 bands from vibrational levels $v' \geq 1$, and predict virtually complete suppression of the [OI] red lines at 100 km in the airglow. The airglow O_2 emission gives $T_{rot}(0\text{-}1) = 183°K$.

6640 NARROW HYDROGEN EMISSION IN THE AURORA. J.M.Malville.

Planet. Space Sci. (GB), Vol. 2, No. 2-3, 130-2 (April, 1960).

In the southern auroral zone during the winter of 1957, H_α was detected which had a width equal to or less than 8 A. This observation is viewed as evidence for proton bombardment without the usual high-velocity auroral particles. The alternate explanation of enhanced fluorescence of interplanetary hydrogen is discussed.

6641 THE ASSOCIATION OF SOLAR RADIO BURSTS WITH AURORAL STREAMS.

A.Maxwell, A.R.Thompson and G.Garmire.

Planet. Space Sci. (GB), Vol. 1, No. 4, 325-32 (Sept., 1959).

Slow drift (Type II) radio bursts from the sun are believed to be caused by a primary disturbance moving outward through the solar atmosphere with a velocity of about 1000 km/sec. Analysis of the 2 years, 1 October 1956 through 30 September 1958, over the sunspot maximum shows that 45% of these bursts are associated with the subsequent occurrence of terrestrial aurorae and magnetic storms. The mean delay between the radio bursts and the terrestrial disturbances is 33 hr, which is in good accord with the velocity for the disturbing source as deduced from the radio data. Investigation of the properties of the individual slow drift bursts and their association with other solar radio and optical phenomena reveals no completely conclusive criteria to explain why only 45% of the bursts are geomagnetically important. The geomagnetic effects are enhanced, however, if the bursts occur near the equinoxes and if they are accompanied by a flare of importance 2 or 3, or by continuum (Type IV) radiation. In the reverse association, with radio data available for an average 14 hr daily, it is shown that at least 60% of magnetic storms are preceded, within 4 days, by a slow drift burst.

6642 PHYSICAL PARAMETERS OF THE ATMOSPHERIC ESCAPE LAYER. J.J.Gilvarry.

Nature (GB), Vol. 188, 804-5 (Dec. 3, 1960).

Results obtained from observations of satellite orbits permit direct inference of various parameters of the atmosphere at the critical escape level. Both the height of this layer and the temperature are found to be greater by day than at night. The values deduced for these quantities are respectively greater than and less than the values inferred from considerations of the dissipation of He^4 from the atmosphere, and the differences may be due to the fact that the dissipation rate is not steady but is linked with transient solar disturbances of duration too short to be revealed by the satellite data. G.M.Brown

6643 THE DUST CLOUD ABOUT THE EARTH. F.L.Whipple.

Nature (GB), Vol. 189, 127-8 (Jan. 14, 1961).

Data from six U.S. rocket firings demonstrate the existence of a relatively high concentration (max. $\cong 10^5$ relative to the interplanetary medium) of dust around the earth. Of four possible explanations to account for this phenomenon, one based on a lunar origin for the dust particles appears most plausible. The dust will be concentrated in the plane of the moon's orbit and have a direct (easterly) motion, the cloud being comparable to that found in the zodiacal plane. It is suggested that attempts might be made during space research experiments to detect and measure both the motion and spatial distribution of the circum-terrestrial dust cloud. D.R.Barber

HYDROMAGNETIC WAVES IN UPPER ATMOSPHERE. See Abstr. 6658

6644 THE CONNECTION BETWEEN MEASUREMENTS WITH THE AID OF CHARGED-PARTICLE TRAPS BY THE SOVIET COSMIC ROCKETS AND MEASUREMENTS OF THE MAGNETIC FIELD BY THE AMERICAN SATELLITE "EXPLORER VI" AND THE ROCKET "PIONEER V".

K.I.Gringauz and S.M.Rȳtov.

Dokl. Akad. Nauk SSSR, Vol. 135, No. 1, 48-51 (Nov. 1, 1960). In Russian.

The authors discuss American models of "ring currents" in the earth's outer atmosphere, which are based on magnetic field measurements by American space probes. (Abstr. 21317-8 of 1960). These are compared with the flux of electrons, with energies exceeding 200 eV, observed by the Soviet cosmic rockets in the outer "radiation belt", at a geocentric distance of about 10 earth radii [Abstr. 14381 of 1960 and Dokl. Akad. Nauk SSSR, Vol. 132, No. 5, 1062 (1960)]. On the hypothesis that the electrons possess a Maxwellian distribution of velocities, the two sets of observations are consistent if the electron temperature is taken to be 230 000°K, corresponding to an energy of 21 eV. The observed particles are considered to belong to the "tail" of the Maxwellian distribution, and further measurements of their energy spectrum are required. [English translation in Soviet Physics—Doklady (USA)]. H.Rishbeth

6645 PROPERTIES OF THE UPPER ATMOSPHERE AND THEIR RELATION TO THE RADIATION BELTS OF THE EARTH. S.F.Singer.

Planet Space Sci. (GB), Vol. 2, No. 2-3, 165-73 (April, 1960).

A theory is developed which gives the distribution of density with altitude for a planetary exosphere in the absence of thermodynamic equilibrium. The results differ considerably from those calculated on the basis of a hydrostatic equation. To apply this theory to the earth's exosphere, the temperature of the base of the exosphere, which is located at 530 km, is first fixed by using satellite drag data between 500 and 1000 km. A temperature of 1500° gives a reasonable fit to the rather sparse data and allows the calculation of the atomic oxygen distribution with altitude. From the cosmic ray neutron albedo theory of the inner (cosmic ray) radiation belt, an upper limit of about 10^6 hydrogen atoms per cm^3 at an altitude of 1000 km can be set. However, the total density including the ionized component must be of the order of $10^{-19} g/cm^3$ at 1000 km. The existence of a minimum between the two observed radiation belts, the so-called "slot", is accounted for in terms of the breakdown of the adiabaticity of the magnetic moment of trapped particles. This same theory also allows statements to be made concerning the mean energy of the trapped protons in the inner radiation belt. It should become progressively softer with increasing altitude. The outer (auroral) radiation belt, which is centred at 3 earth radii, has a lifetime which is controlled primarily by the presence of a scattering atmosphere. From a theory which takes into account both energy loss and scattering, the intensity contours for the quasi-equilibrium state can be calculated. Special techniques give the transient case following the injection of particles into this region. The initial injection of solar corpuscular radiation consists mainly of protons and electrons with velocities of 2×10^8 cm/sec. These 20 keV protons form a third and rather transient (~ 1 day) radiation belt at 4-8 earth radii; they account for most of the effects observed during magnetic storms. Their initial diamagnetic effects produce the "reverse sudden commencement" (SC*). Their increase of upper atmosphere ionization accounts for the sudden commencement currents while their drift in longitude accounts well for the main phase of magnetic storms. In comparing various removal processes for the injected protons, it is found that charge exchange is about 100 times more effective than atmospheric scattering. Using the theoretical distribution for the hydrogen exosphere, the complete development of a magnetic storm can be calculated as a function of time, including the distribution around the earth of trapped protons as well as their magnetic effects.

MEASUREMENTS OF RADIATION DURING THE FLIGHT OF THE THIRD COSMIC ROCKET. See Abstr. 4815

6646 THE ESTIMATION OF SOME PARAMETERS DESCRIBING THE NON-UNIFORMITY OF SOLAR CORPUSCULAR STREAMS. M.S.Bobrov.
Astron. Zh. (USSR), Vol. 36, 601-15 (1959). In Russian.

By examination of high-latitude magnetograms, some parameters of the high-density regions in solar corpuscular streams are estimated. These are the size, mean separation, and the magnetic field intensity of such condensations. The size of the condensations is estimated to be of the order 100-300 km, which is about one fortieth of the estimated distance between condensations. The internal magnetic field intensity is estimated to lie between 10^{-4} and 10^{-2} Oe. [English translation in: Soviet Astron.—AJ (USA), Vol. 5, No. 4, 588-600 (Jan.-Feb., 1960)]. K.G.Major

GEOMAGNETISM

SCALE TIMES AND LENGTHS IN GEOMAGNETISM. See Abstr. 5185

ROTATING COIL MAGNETOMETER FOR THE MEASUREMENT OF THE EARTH'S MAGNETIC FIELD. See Abstr. 5525

6647 THE MAGNETIC DECLINATION IN TRANSYLVANIA. G.Atanasiu, T.Neştianu and I.Bucur.
Stud. Cercetari Fiz. (Roumania), Vol. 10, No. 3, 481-503 (1959). In Roumanian.

Reports on a comprehensive series of measurements of the magnetic inclination in Transylvania carried out at 97 geomagnetic stations during the period 1951-1958. The results are presented in the form of a sufficiently detailed map of the region with the isoclines superposed. The methods of measurement and the corrections applied are discussed in the text. S.J.St-Lorant

6648 LINES OF FORCE OF THE GEOMAGNETIC FIELD IN SPACE. E.H.Vestine and W.L.Sibley.
Planet. Space Sci. (GB), Vol. 1, No. 4, 285-90 (Sept., 1959).

The lines of force of the geomagnetic field at various latitudes and longitudes in the northern hemisphere are approximately traced to their intersections with the earth's surface in the southern hemisphere, using an electronic computer and the firs nine Gauss coefficients. Those lines leaving the average northe auroral zone are traced to their intersection of the geomagneti field with the earth's surface. These points of intersection are found to be very nearly at the average soutern auroral zone ded from auroral observations and from magnetic measurements of disturbance. It is concluded, therefore, that the geomagnetic fie has stability and a simple character even at distances as great as about 6 earth radii above the earth, measured in the equator plane, even during auroral displays. It is also concluded that solar streams at such times do not seriously distort the field li connecting the auroral zones.

MAGNETIC FIELDS AND ELECTRON FLUX IN THE OUTE RADIATION BELT. See Abstr. 6644

6649 SOME ASPECTS OF THE FIRST HIGH-FREQUENC GEOMAGNETIC RECORDINGS OBTAINED AT GAR
H.Fournier.
C.R. Acad. Sci. (France), Vol. 251, No. 7, 962-4 (Aug. 17, 1960). French.

"High-frequency" geomagnetic variations (greater than 1 c/ have very different properties from variations with lower freque They are continuous, more or less random, and display no abru changes in amplitude or period. A 0.12 sec oscillation is prese all times. S.

6650 APPROXIMATE EMPIRICAL RELATION BETWEEN THE SECULAR MAGNETIC VARIATION AND THE FLUCTUATIONS OF THE EARTH'S ROTATION. L.Cagniard.
C.R. Acad. Sci. (France), Vol. 251, No. 10, 1142-4 (Sept. 5, 1960 In French.

Random fluctuations in astronomical time may be associated with random fluctuations in the earth's rotational velocity. Stoy gave an approximate formula between magnetic field and time fluctuations, erroneously inferring a proportional relation betwe geomagnetic moment and rotational velocity. Such a relation is unreasonable, chiefly because of the large discrepancy in magni of variations in magnetic field and in angular velocity. An empi relation is given between the vertical component of the magnetic moment of the central dipole and random fluctuations in astronomical time. S.K

6651 THE QUESTION OF GEOMAGNETIC OBSERVATION BY THE FIRST SOVIET COSMIC ROCKET.
M.G.Antsilevich and A.D.Shevnin.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 2, 298-300 (Nov. 11, 1960). Russian.

Observations by the cosmic rocket launched on 2nd January, 1959, showed a rapid increase of the magnetic field at a geocentr distance of 22 000 km (Abstr. 3340 of 1960). This is attributed t "ring current" of 5×10^5 A, flowing in a layer about 1000 km thi Records from 16 magnetic observatories and two earth-current recording stations for this date show a small sudden commencem followed by a minor magnetic storm; the greatest amplitude of th aperiodic D_{st} component of the horizontal field being about 20 ga It is shown that the "ring current" deduced from the rocket obse vations could account for the magnetic disturbance. H.Rish

6652 SOLAR CORPUSCULAR STREAMS AND FAMILIES GEOMAGNETIC STORMS. V.I.Afanas'eva.
Dokl. Akad. Nauk SSSR, Vol. 135, No. 5, 1120-2 (Dec. 11, 1960). In Russian.

Weak magnetic storms are often accompanied by "families" geomagnetic disturbances, in the days preceding and following th storm, which seem to be created by corpuscles ejected from a stream in the neighbourhood of the earth. The density of the corpuscles is inversely proportional to the square of the shortes distance of the stream from the earth. Investigation of the famil indicates that the earth is seldom completely immersed in a stre but that the majority of magnetic storms are caused by the close passage of a stream to the earth. [English translation in: Soviet Physics—Doklady (USA)]. G.A.Chis

6653 MAGNETIC STORMS AND COSMIC RADIO NOISE ON 25 Mc/s AT AHMEDABAD (23°02' N; 72°38' E).
R.V.Bhonsle and K.R.Ramanathan.
Planet. Space Sci. (GB), Vol. 2, No. 2-3, 99-103 (April, 1960).

Analysing the intensities of cosmic radio noise on 25 Mc/s a

Ahmedabad, it was found that during days of magnetic storms there was, in addition to the usual variation of intensity due to the diurnal changes in D-region ionization and F-region absorption, a further variation. This showed itself as a decrease in the attenuation on the first two days of the storm and an increase in the attenuation on the third day. The decreased attenuation is most clearly seen in the first half of the night on the first and second days after the commencement of a storm and is associated with a decrease in F-scatter.

6654 IDEALIZED PROBLEMS OF PLASMA DYNAMICS RELATING TO GEOMAGNETIC STORMS. S.Chapman.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 919-33 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). As with hydrodynamics, progress in hydromagnetics seems likely to come along two main lines — from general theorems, and from solutions of particular problems. In the latter, the fluid considered may be idealized in some respects. For application to real fluids, the consequences of the neglected properties must later be considered. Ferraro and the author in 1940, and Ferraro in 1952, solved by "particle" methods two particular hydromagnetic problems that bear on the first phase of geomagnetic storms. The main features of these problems and of their solutions are described, and some parts of the solutions are illustrated more fully. The changes in the solutions if account is taken of some neglected factors are discussed — particularly as regards the thermal motions and collisions of the particles, and as regards the oblique impact of some of the particles on the magnetic field. Some further idealized problems are formulated, which are probably soluble by similar methods, and which seem likely to increase our understanding of hydromagnetics and of geomagnetic storms.

6655 THEORY OF SUDDEN COMMENCEMENTS AND OF THE FIRST PHASE OF A MAGNETIC STORM.
V.C.A.Ferraro.
Rev. mod. Phys. (USA), Vol. 32, No. 4, 934-40 (Oct., 1960).

Magneto-fluid Dynamics Symposium (see Abstr. 4700 of 1961). A first attempt is made to modify the theory of sudden commencements and of the first phase of magnetic storms developed by Chapman and the author (1940) so as to take account of the presence of the ionized interplanetary gas. After reviewing the evidence in favour of the corpuscular theory of magnetic storms, a brief account is given of the original form of the theory of the first phase whereby currents are induced in the surface layers of a solar corpuscular stream by its motion across the geomagnetic field. The modification of the theory due to the presence of the interplanetary gas is considered. Because the stream surface is impervious to the external magnetic field and because the lines of force tend to be frozen in the interplanetary gas, as the stream surface advances into this, a simple type of "shock wave" seems likely to develop in the interplanetary gas ahead of it, much as an ordinary shock wave develops ahead of a piston advancing into a cylinder of gas. Near the earth, the shock wave will travel approximately with the local Alfvén velocity in the interplanetary gas. Its time of travel from a distance of about 5 earth radii to the earth is of the order of a minute for particle densities of 1000 cm^{-3} whilst the increase in the magnetic horizontal force appears to be comparable with that which would be attained in the absence of any interplanetary gas. Thus, whilst some modifications are necessary to the theory, substantially it remains unaltered.

GEOMAGNETIC STORM ON 7 JULY 1958. See Abstr. 6614

6656 THE MAGNETIC PINCH EFFECT IN A FREE MOLECULAR PLASMA STREAM (A CONTRIBUTION TO THE THEORY OF FLOW AROUND THE MAGNETIC DIPOLE OF THE EARTH BY CORPUSCULAR STREAMS FROM THE SUN).
V.N.Zhigulev.
Dokl. Akad. Nauk. SSSR, Vol. 135, No. 6, 1364-6 (Dec. 21, 1960).
In Russian.

The process of circulation of a free molecular flow of plasma around magnetized bodies is considered assuming the basic linear parameter of the interaction to be large compared with thickness of the reflecting layer and exceeding the dimensions of the body (i.e. the body is fully inside the cavity). The general problem of the magnetic pinch effect is treated. The results are applied to the problem of flow of free molecular corpuscular streams from the sun around the magnetic dipole of the earth. [English translation in: Soviet Physics—Doklady (USA)]. F.Herbut

6657 STRESS EFFECTS ON THERMOREMANENT MAGNETIZATION. J.M.Hall and R.N.Neale.
Nature (GB), Vol. 188, 805-6 (Dec. 3, 1960).

Experiments have shown that the effect of stress on a rock acquiring a thermoremanent moment is not completely reversible as previously reported [P.M.Stott and F.D.Stacey, Nature (GB), Vol. 183, 384 (Feb. 7, 1959)]. Positive results were obtained with material from a dolerite dyke in Skye (Scotland) and also in materials containing pyrrhotite, an ilmenite—haematite solid solution and a magnetite—ilmenite solid solution. The mechanism of the process appears to be complex. D.J.Oliver

PALAEOMAGNETIC EVIDENCE RELEVANT TO A CHANGE IN THE EARTH'S RADIUS. See Abstr. 5133

LABORATORY STUDY OF ARTIFICIAL MAGNETIC ROCKS. See Abstr. 6277

6658 EVIDENCE OF QUASI-PERPENDICULAR PROPAGATION OF HYDROMAGNETIC WAVES CAUSED BY NUCLEAR EXPLOSIONS OVER JOHNSTON ISLAND. H.Maeda and T.Ondoh.
Nature (GB), Vol. 188, 1018-19 (Dec. 17, 1960).

Double geomagnetic field changes recorded at two Japanese stations immediately following each of the two nuclear explosions in the high atmosphere over Johnston Island in August 1958 are used to determine the propagation velocities of the hydromagnetic waves from the explosion and the damping distance in which the waves are attenuated by a factor e^{-1}. The results are not consistent with the prevailing theory of propagation of hydromagnetic waves in a partially ionized plasma in the case when the wave path is approximately perpendicular to the geomagnetic field lines. A suggested alternative mechanism is put forward. J.M.Stagg

BIOPHYSICS . PHYSIOLOGICAL PHYSICS

6659 X-RAY MICROSCOPY — RETROSPECT AND PROSPECT. V.E.Cosslett.
rit. J. Radiol., Vol. 34, 1-20 (Jan., 1961).

This is the Sylvanus Thompson Memorial Lecture of the British nstitute of Radiology, and it reviews the development of the different methods of microradiography: the contact, reflection and projection echniques. Quantitative elementary analysis with X-rays, by the aborption and emission methods, is also discussed and some examples n biology, mineralogy and metallurgy are briefly described. V.E.Cosslett

MICROSCOPY OF BIOLOGICAL SPECIMENS. See Abstr. 4426

PHOTOMICROGRAPHIC MICROSCOPE FOR BOTH MICRO AND MACRO APPLICATION. See Abstr. 4449

ENERGY TRANSFER WITH SPECIAL REFERENCE TO BIOLOGICAL SYSTEMS. See Abstr. 4920

THE IMPORTANCE OF VACUUM TECHNIQUES IN THE PRODUCTION OF STABLE BLOOD PREPARATIONS. See Abstr. 5316

CALORIMETER FOR THE CONTINUOUS STUDY OF THE HEAT PRODUCTION OF MICROBIAL SYSTEMS. See Abstr. 5371

QUANTITY AND QUALITY OF SCATTERED X-RAYS IN RADIOTHERAPY. See Abstr. 5710

Hearing . Speech

6660 CALCULATING THE ARTICULATION IN NOISY ROOMS. E.E.Golikov.
Akust. Zh. (USSR), Vol. 6, No. 3, 409 (1960). In Russian.

The criterion for the articulation quality of rooms (Abstr. 3114 of 1957; 3838 of 1958) is now extended to take account of noise interference. A graph relating the criterion to syllable articulation is presented. [English translation in: Soviet Physics-Acoustics (USA), Vol. 6, No. 3, 407-8 (Jan.-March, 1961)]. H.D.Parbrook

6661 INTELLIGIBILITY OF TIME-COMPRESSED SPEECH. R.G.Klumpp and J.C.Webster.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 265-7 (March, 1961).

By automatically reassembling periodic samples of recorded speech, Fairbanks and associates have shown that comprehension is good for: (1) connected speech compressed 50% in time (to 0.5), and (2) a single well-learned PB list compressed up to 0.15. In 1919-1925 Fletcher and associates, using turntable speedup with its attendant frequency distortion, found that the intelligibility of syllables began to drop rapidly at speedups corresponding to time reductions of 0.8 (down about 25% at 0.7). In one case a complex technique using simple language showed only slight losses in comprehension for large time compressions. In the other case, a simple technique using difficult speech material showed marked deterioration. In this work on message (simple language) storage schemes, the desirability of obtaining time-compressed speech with simple modifications of existing equipment has become evident. By merely speeding up the playback of a tape recorder, it was found that numbers and simple phrases can tolerate a time compression of 0.67 without serious losses in intelligibility, and PB words lose only 10% in intelligibility with a time compression of 0.75.

6662 TRANSITIONS, GLIDES, AND DIPHTHONGS. I.Lehiste and G.E.Peterson.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 268-77 (March, 1961).

The study deals with the formant movements associated with transitions, glides, and diphthongs in spoken American English. The transitional characteristics associated with all initial and final consonant phonemes were studied in a large sample of utterances. The rate of change of the transition from a consonant hub to the steady state vowel formant position and conversely was investigated for vowels which are commonly considered monophthongs. It is assumed that such changes are cues for the perception of the consonants rather than linguistically significant components of the vocalic nucleus. The rate of change associated with syllable nuclei commonly perceived as diphthongs, [ɑI], [ɔI], [ɑU] was investigated and compared with the changes due to consonant transitions in monophthongs. Criteria are suggested by which the formant movements due to transitions may be distinguished from movements that have linguistic signalling value within the syllable nucleus.

6663 PITCH SENSATION AND ITS RELATION TO THE PERIODICITY OF THE STIMULUS. HEARING AND SKIN VIBRATIONS. G.v.Békésy.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 341-8 (March, 1961).

It has been suggested that the nervous system of the ear is capable of identifying the periodicity of a complex sound, as such, isolated from other factors. Because many phenomena in hearing have their counterparts in the vibratory sensations of the skin, the question is analysed whether the skin also is able to identify and isolate periodicity of the stimulus. Since a phenomenon described by Seebeck 100 years ago seems to provide the best demonstration of periodicity perception in hearing, an analogous phenomenon on the skin has been investigated for both mechanical and electrical stimulation. The skin too showed the Seebeck phenomenon. But it became obvious that on the skin it is possible to change the periodicity without altering the "pitch sensation" or to change the pitch sensation without having modified the periodicity. The pitch sensation for complex sounds and complex vibrations is probably not a simple process.

6664 EFFECT OF ANOXIA ON COCHLEAR POTENTIALS. T.Konishi, R.A.Butler and C.Fernandez.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 349-56 (March, 1961).

The anterior inferior cerebellar artery of guinea pigs was occluded, thereby interrupting the blood supply to the cochlea. Durations of occlusion ranged from 1 through 60 min. Cochlear microphonics, summating potential, action potential, and endocochlear potential were recorded before, during, and subsequent to occlus
The differential effect of anoxia on the various potentials was ob
served, as well as the appearance of the large negative d.c. pote
in scala media as anoxia progressed. For the brief occlusion du
tions, the amplitudes of all potentials except cochlear micropho
became greater than normal soon after the blood supply returne
Even for the longer anoxic intervals, the summating potential an
the endocochlear potential exhibited supernormality during the r
covery process.

6665 SIMULTANEOUS DICHOTIC FREQUENCY DISCRIMI TION. D.W.Odenthal.
J. Acoust. Soc. Amer., Vol. 33, No. 3, 357-8 (March, 1961).

It is found that in the frequency range below 100 c/s, an app
mately constant frequency difference (11-14 c/s) is needed to ob
a just noticeable interaural difference in pitch; between 1000 and
1500 c/s the limen rapidly increases. At 1500 c/s, it amounts to
some 60-75 c/s, or 4-5%. The percentage sensitivity then rema
constant up to some 2400 c/s. Between 2400 and 3000 c/s there
second sharp rise of the limen, which reaches a value of 300 c/s
(or 10%) at the latter frequency. Between 3000 and 8000 c/s, the
percentage sensitivity remains constant at about 10%.

6666 VOWEL RECOGNITION USING A MULTIPLE DISCRIMINANT FUNCTION. J.E.K.Smith and L.Kle
J. Acoust. Soc. Amer., Vol. 33, No. 3, 358 (March, 1961).

An application of statistical detection theory to automatic
speech recognition is presented. The multiple discriminant func
approach is applied to the problem of vowel recognition. Twenty
one speakers, 10 females and 11 males, produced 215 single vow
words, exemplifying ten different vowels. The linear discrimina
function correctly labelled 87% of the utterances; the quadratic d
criminant function correctly labelled 94%. It is pointed out that
detections were achieved without use of duration information and
without explicit use of formant information.

6667 LOUDNESS FUNCTION AND DIFFERENTIAL SENS TIVITY OF THE INTENSITY. I.Barducci.
Ricerca sci. (Italy), Vol. 30, No. 10, 1518-23 (Oct., 1960).

In a recent paper Schiaffino [Abstr. 1556 B of 1958; Ann. Te
comm. (France), Vol. 12, No. 10, 349-58 (Oct., 1957)], has prop
a method for deducing the loudness function from the experime
values of the differential sensitivity for the sound intensity. A
critical analysis is given of this method and some modifications
proposed in order to account for the more recent experimental
on the loudness function obtained by Robinson (Abstr. 14763 of
The agreement between the calculated and the experimental loud
function is fairly good.

Vision

6668 PERIAXIAL ABERRATIONS OF THE EYE. I. A.Biot.
Ann. Soc. Sci. Bruxelles (Belgium), Vol. 74, No. 3, 175-88 (1960
In French.

Aberrations are discussed which arise from the non-coincid
of the visual and optic axes of the human eye. R.A.W

6669 A FURTHER STUDY OF PULSE-TO-CYCLE FRACT AND CRITICAL FLICKER FREQUENCY. A DECISI THEORETICAL TEST. S.H.Bartley and T.M.Nelson.
J. Opt. Soc. Amer., Vol. 51, No. 1, 41-5 (Jan., 1961).

Various curves relating CFF to log I cross each other when the
curves represent different PCF's (pulse-to-cycle fractions). Th
has been interpreted to mean that PCF and conditions of flicker
fusion are not simply related, as has been generally taken for
granted. It was supposed that, whereas short pulses in a given
repetitive cycle would produce flicker and longer pulses would
produce fusion, still longer ones would reintroduce flicker, and
finally the longest ones would produce fusion. An electronic fusi
apparatus producing square waves and varying PCF from 0.02 to
0.98 was used to test this directly. PCF was varied over this ra
while CFF (and thus cycle length) and intensity were held consta
The supposition was readily confirmed. In addition, data were
collected suggesting that the very shortest pulses would produce
fusion rather than flicker at some intensity levels.

6670 THE PERCEPTION OF MOVEMENT PERSISTENCE IN THE GANZFELD. J.W.Miller and E.Ludvigh.
J. Opt. Soc. Amer., Vol. 51, No. 1, 57-60 (Jan., 1961).

The apparent persistence of seen movement in a homogene visual field (Ganzfeld) is described. The task required that the subject observe the movement of a single, black, spherical stimulus in an otherwise empty field and to report when its movement ceased. The time interval between real and apparent cessation of movement was defined as "time delay". The hypothesis advanced states that the apparent speed of the stimulus in the Ganzfeld is dependent upon the square of its real velocity, its duration and its size. This may be expressed as $t = r + (1/av^2)$ where t = time delay, r = reaction time, v = velocity, and a = the constant of inverse proportionality. The data are discussed in terms of "contrast of velocity". The notion here is that a stimulus travelling at high speed and for a relatively long duration produces a more definite perception of velocity than one travelling slowly and observed for a shorter period of time. Therefore, when the former stimulus suddenly is stopped, the resulting contrast of velocity is great and the response to it rapid, whereas when the latter stimulus is similarly stopped, the resulting contrast of velocity is slight and its perception therefore slower. The data were shown to support this hypothesis.

6671 STUDY OF FLICKER BY INCREMENT THRESHOLD TECHNIQUE.

R.M.Boynton, J.F.Sturr and M.Ikeda.
J. Opt. Soc. Amer., Vol. 51, No. 2, 196-201 (Feb., 1961).

Increment thresholds of a small test flash are measured with the flashes superposed upon a flickering background stimulus. Instrumentation is described that permits accurate temporal positioning of the test flash within the light-dark cycle of the background field, and allows rapid threshold measurements to be obtained for the test flash in any desired temporal position. It is found that the increment threshold rises with the light phase and falls with the dark and that this undulation in threshold (believed related to "on-responses" in the human visual system) persists even when the luminance of a 30 c/s flickering background stimulus is made too low for the flicker to be perceptible. Other experiments are also described and interpreted.

6672 ACCOMMODATION AND SCOTOPIC VISUAL ACUITY.

S.M.Luria.
J. Opt. Soc. Amer., Vol. 51, No. 2, 214-19 (Feb., 1961).

Changes in scotopic acuity as a function of varying states of natural accomodation have been measured with targets at various distances and luminances. Results for two observers showed that the amounts of negative accommodation needed to produce maximum acuity increased with decreasing luminance or increasing target distance at a constant luminance. The amount of natural negative accommodation needed for maximum acuity was much less than has been found with the use of spectacles and natural accommodation for infinity. There appeared to be a critical luminance level at which changes in accommodation produced minimal changes in acuity. The effect of red vs white fixation lights was also investigated.

6673 EYE'S RESPONSE AT FLICKER FUSION TO SQUARE-WAVE MODULATION OF A TEST FIELD SURROUNDED BY A LARGE STEADY FIELD OF EQUAL MEAN LUMINANCE.

H.de Lange Dzn.
J. Opt. Soc. Amer., Vol. 51, No. 4, 415-21 (April, 1961).

With two electrical analogue of the brightness system it is shown that at a low luminance level (< 5 photons) and in the low-frequency region (< 2 c/s), when under the special visual conditions no attenuation in the system occurs and with a symmetrical luminance variation such as a sinusoidal modulation or a square-wave modulation with a 1 : 1 on-off ratio, half the crest-to-trough value of the percentage variation at flicker fusion equals the internal threshold value r_0; but with an asymmetrical variation such as a square-wave modulation with a 1 : 3 on-off ration it is the crest value of the periodical percentage variation above the mean luminance level which at flicker fusion equals the internal threshold value r_0. At high luminance levels an overshoot in the low-frequency region occurs with both forms of square-wave modulation in accordance with the shape of the attenuation characteristic (AC) of the system under the experimental circumstances. At the steep slope of the ACs for the whole luminance range in cone vision, half the crest-to-trough value of the Fourier fundamental percentage variation at the site of the threshold mechanism located anywhere in the system, equals the internal threshold value r_0 at flicker fusion.

6674 VISUAL RESPONSES TO TIME-DEPENDENT STIMULI. I. AMPLITUDE SENSITIVITY MEASUREMENTS.

D.H.Kelly.
J. Opt. Soc. Amer., Vol. 51, No. 4, 422-9 (April, 1961).

With sinusoidal modulation of the radiance of the stimulus as a function of time, amplitude thresholds are measured instead of the repetition-rate thresholds usually obtained in flicker-fusion experiments. Controlling the modulation amplitude independently of the time-average radiance provides an additional degree of freedom, so that the observer's adaptation level can be held constant while his amplitude senstivity is measured as a function of the modulation frequency. With an "edgeless" flickering field, these amplitude sensitivity curves show a broad peak of maximum visual response, in the region from 10 to 20 c/s at high photopic levels. Such classic relationships as the Ferry—Porter, Talbot—Plateau, and Weber—Fechner laws are derivable from the present results, as descriptions of the behaviour of certain parts of the amplitude sensitivity curves as functions of adaptation level.

6675 TWO-COLOR THRESHOLD AS TEST OF COLOR VISION. R.M.Boynton and M.Wagner.

J. Opt. Soc. Amer., Vol. 51, No. 4, 429-40 (April, 1961).

The two-colour threshold is obtained by finding the just-visible luminance of a test flash of one colour, seen against a background of another colour. For normal observers, threshold luminance for such heterochromatic conditions is lower than when the test and background stimuli are of the same colour. The factor by which colour differences alone reduce the increment threshold is defined as the heterochromatic threshold reduction factor (HTRF). A colour test capable of measuring the HTRF is devised and applied to 67 subjects, 21 of whom are red-green defective according to five independent criteria. When filtered red and green stimuli are used, the HTRF is shown to be zero for most colour-defective subjects, within the limits imposed by measurement error. For normal subjects, the average red-green HTRF varies from about 2 to 4, depending upon conditions. An examination of green-on-red thresholds plotted against red-on-green thresholds reveals a separation of normal subjects from the colour-defectives, and also makes discriminations within the colour-defective group. The test as a whole misclassifies no normals as defective, properly classifies all colour defectives as such, and very clearly classifies all colour defectives as to gross type (protan versus deutan). Further work must be done to evaluate the test's ability to discriminate dichromats from anomalous subjects, although the results in hand are very promising. Within the colour-defective group, the test seems to provide a quantitative assessment of the degree of colour defect; it also appears capable of detecting weak normals.

6676 EFFECT OF RETINAL IMAGE MOTION ON VISUAL ACUITY. O.Bryngdahl.

Optica Acta (Internat.), Vol. 8, No. 1, 1-16 (Jan., 1961).

An attempt to correlate visual acuity measurements with eye movements was made. The linear filter theory (applicable only as far as small retinal illumination increments are concerned) was applied to the eye/lens/retina system. A description of the transmission of spatial information over a single-channel system was used. This requires translation of intensity functions into one-dimensional time-functions by the scanning motion of the eye. An image sharpening mechanism of the eye can be related to an overall sine-wave response characteristic which decreases at very low line numbers. In this way the visual acuity of single-line targets can be explained.

6677 THE SATURATION OF SPECTRAL COLOURS VIEWED IN A SMALL FIELD. K.J.McCree.

Optica Acta (Internat.), Vol. 8, No. 1, 21-4 (Jan., 1961).

Saturation was derived from the quantity of spectral light which had to be added to white to produce a perceptible change of colour. When the field size was reduced from 80' to 15', at a retinal luminance of 50 trolands, the saturation fell to zero in the yellow, and was much reduced in the blue-violet. The effect of using different reference-whites was also investigated; with a white of lower colour temperature, the minimum of saturation occurred at a longer wavelength.

6678 SMALL-FIELD TRITANOPIA AND THE EFFECTS OF VOLUNTARY FIXATION. K.J.McCree.

Optica Acta (Internat.), Vol. 7, No. 4, 317-23 (Oct., 1960).

Recently published wavelength discrimination curves for point sources have shown no tritanopic confusion of blue and green, and it has been suggested that this was because the observers scanned the field, instead of fixating on it. Curves measured by the author, also without fixation, but over a different range of field sizes and luminances, do show tritanopic confusion, although it is not as marked as in the older investigations. The curves also show that lowering the luminance, at a given field size, produces a different effect, and that discrimination between blue and violet, at 430 $m\mu$, can be very good when fixation is avoided.

6679 CHANGES IN THE POSITIONS OF THE INVARIANT COLOURS WITH THE STATE OF ADAPTATION OF THE EYE.

E.G.T.Wassef and E.Aziz.

Optica Acta (Internat.), Vol. 7, No. 4, 341-54 (Oct., 1960).

The colours which retain their daylight appearances to each of five observers under three cases of chromatic adaptation and one case of white adaptation were determined from binocular matching data. The assumption of the linearity of the relationship between the tristimulus values of the corresponding colours which underlies the analytical treatment of the data is shown to be fulfilled in all the cases, the evidence being the agreement between the observed matches and those computed from the linear transformation. The invariant colours under each of the adaptation conditions were calculated for each observer and also from the mean matches of all the observers. The scatter of the individuals' invariants about the invariants obtained from the mean matches provides a criterion for testing the significance of the changes of the latter from one state of adaptation to the other. The analysis clearly reveals significant changes of the invariants in two regions.

6680 UNIVERSALLY APPLICABLE SCALE OF BRIGHTNESS SENSATION.

H.W.Bodmann.

Lichttechnik (Germany), Vol. 13, No. 1, 19-21 (Jan., 1961). In German.

Examines the application of the formula $H = B/(B + B_a)$ to establish a scale of luminosity (brightness sensation) in terms of B, the luminance of the test object, and B_a, the luminance to which the eye is adapted. It is shown that, where B and B_a do not differ greatly, the Weber—Fechner relation applies and ΔH varies as $\Delta B/B$. Where B_a is much greater than B, ΔH is approximately proportional to ΔB, while where B_a is small ΔH varies as $\Delta B/B^2$. There are also zones, between these regions, where the relationship is changing. The application of these results to practical problems in lighting is discussed. J.W.T.Walsh

6681 PYROMETRIC MEASUREMENT OF THE ABSOLUTE VISUAL THRESHOLD.

E.Baumgardt.

Optica Acta (Internat.), Vol. 7, No. 4, 305-16 (Oct., 1960). In French.

The absolute visual threshold at the corneal level was measured using a precise pyrometric method. For green light of 520 $m\mu$ wavelength, the results do not differ essentially from t published by Hecht, Shlear and Pirenne (1942). It is concluded the absorption of seven light quanta is sufficient to produce a liminal light sensation.

6682 EXTRA-FOVEAL COLOUR METRICS.

F.J.J.Clarke.

Optica Acta (Internat.), Vol. 7, No. 4, 355-84 (Oct., 1960).

A series of monochromatic equal-brightness stimuli of su $40' \times 80'$ was established through the spectrum by direct comp with a neighbouring 530 $m\mu$ patch of retinal illumination 10.8 trolands. The separated test and comparison fields lay at 10^0 eccentricity in the nasal meridian, had dark surrounds and wer viewed by a flash-and-recovery cycle, using 2 or 30 flashes to establish the matches. These test stimuli were subsequently by comparison with a foveal patch consisting of matching stim 650 $m\mu$, 530 $m\mu$ and 460 $m\mu$, results being plotted as a spectrum l the foveal chromaticity chart. Luminous efficiency functions w determined, both for heterochromatic matching and by computa from the foveal comparison colour matches. Selected colour s were also matched using 4, 8, 16 or 30 flashes to establish the matches, and it was found that the matches varied systematica with the number of flashes. Series of equal-brightness mixtur of 430 and 530 $m\mu$ and 480 and 650 $m\mu$ were calculated (assum additivity to hold), and these were matched in both foveal and e foveal RGB systems. Gross failures of both chromatic and ph metric additivity were always found. In a theoretical appendix shown that the presence of rod intrusion does not lead to additi failures if there is no interaction between cone and rod respon With cone—rod interaction it is shown that general additivity fa occurs, whether the RGB comparison field is presented either foveally or extra-foveally.

6683 SOME FACTORS IN BRIGHTNESS DISCRIMINATI WITH CONSTRAINT OF RETINAL IMAGE MOVEMENT.

M.B.Clowes.

Optica Acta (Internat.), Vol. 8, No. 1, 81-91 (Jan., 1961).

A study was made of the discrimination of a luminance difference between the segments of a bipartite field, using the stabilized retinal image. It is shown that there is a simple correlation between the amplitude of retinal image motion an level of visual discrimination measured by a time-average procedure. In the absence of retinal image motion, separatio the comparison stimuli further impairs discrimination. Thes phenomena are discussed in the light of recent electrophysiol studies of the mammalian eye.

TECHNIQUE . MATERIALS

6684 THE JOINT CONFERENCE OF THE NON-DESTRUCTIVE TESTING GROUP AND THE SOCIÉTÉ FRANÇAISE DE METALLURGIE.

Brit. J. appl. Phys., Vol. 12, No. 4, 125-46 (April, 1961).

A general report of the conference which was held at the Institution of Mechanical Engineers, London from 2-4, May, 1960. A list is included of all papers presented and, where available, references are given for those which have been or will be published. The report is followed by four papers, abstracts of which will appear in this or succeeding sources of Physics Abstracts.

6685 APPARATUS FOR THE MECHANICAL INVESTIGATION OF METALS UNDER PRESSURES UP TO 30 000 kg/cm^2.

Yu.N.Ryabinin, L.F.Vereshchagin, D.B.Balashov and L.D.Livshits.

Pribory i Tekh. Eksper. (USSR), 1958, No. 2, 79-85 (March-April). In Russian.

An installation is described giving hydrostatic pressures up to 30 000 kg/cm^2 in a liquid enclosed in a volume 13 mm diameter and 40-70 mm long. The operation of a thick-walled vessel with an outside conical support is considered. A description is given of a seven-channel connector, a manganin resistance manometer, and an arrangement for testing metallic samples in tension under high hydrostatic pressure. [English translation in: Instrum. exper. Tech. (USA), No. 2, 265-72 (March-April, 1958; publ. April, 1959)].

6686 AN APPARATUS OF A SUPER-HIGH PRESSURE WITH A SIMULTANEOUS ACHIEVEMENT OF HIGH TEMPERATURES.

S.S.Boksha and G.P.Shakhovskoi.

Pribory i Tekh. Eksper. (USSR), 1958, No. 3, 86-90 (May-June In Russian.

The apparatus is capable of compressing gases to pressur to 30 000 kg/cm^2 with the simultaneous chievement of tempera up to 2000^0 C. The method of obtaining super-high gas pressur means of dry ice is also described. The dependence of the me points of aluminium and copper on pressure was investigated a black crystalline phosphorus was obtained from the melt. It w shown that the melting point of Al and Cu increases with press In the temperature and pressure ranges investigated the modif cations of phosphorus found were the amorphous and the crysta black phosphorus only. [English translation in: Instrum. exper Tech. (USA), No. 3, 415-19 (May-June, 1958; publ. June, 1959)

6687 SEALING MOLYBDENUM LEADS TO ALUMINO-SILICATE GLASS.

M.Liebson.

Rev. sci. Instrum. (USA), Vol. 32, No. 2, 204-5 (Feb., 1961).

6688 VACUUM-ARC EVAPORATION OF REFRACTORY METALS.

M.S.P.Lucas, H.A.Owen, Jr, W.C.Stewart and C.R.Vail.

Rev. sci. Instrum. (USA), Vol. 32, No. 2, 203-4 (Feb., 1961).

Tantalum was evaporated at 20 A/sec at a distance of 2 c stainless steel at a much faster rate, using evaporation from a vacuum arc. Thin films of niobium and vanadium were also ob by this method. V.J.Ha

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Vol. 64 (1961). Reprints of the List of Journals can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s.0d. post free. The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

An. Stiint. Univ. "Al.I.Cuza" Iasi (Ser. noua) (Roumania)	Analele Ştiinţifice ale Universitătii "Al. I. Cuza" din Iasi (Serie nouă). Secţiunea I (Matematică, Fizică, Chimie). Iasi.
Mem. Soc. Roy. Sci. Liege (Belgium)	Memoires de la Société Royale des Sciences de Liège. Collection in-4; Collection in-8. L'Université, 7 Place de 20 Août, Liège.
Notes appl. Sci. Nat. Phys. Lab. (GB)	Notes on Applied Science. National Physical Laboratory Teddington, Middlesex. Publishers: HM Stationery Office, Kingsway, London, WC 2.
Quart. J. Mech. appl. Math. (GB)	Quarterly Journal of Mechanics and Applied Mathematics Clarendon Press, Oxford.
RC Semin. Mat. Fis. Milano (Italy)	Rendiconti del Seminario Matematico e Fisico di Milano Publishers: Libreria Editrice Politecnica, Tamburini, Milano.
Rep. Liberal Arts Sci. Fac. Shizuoka Univ. (Nat. Sci.) (Japan)	Reports of Liberal Arts and Science Faculty, Shizuoka University (Natural Science) Shizuoka University, Ôiwa-2, Shizuoka.
Rev. Acad. Cienc. Zaragoza (Spain)	Revista de la Academia de Ciencias Exactas, Fisico-Quimicas y Naturales de Zaragoza Plaza de Paraiso 1, Zaragoza.
Smithsonian Contrib. Astrophys. (USA)	Smithsonian Contributions to Astrophysics Smithsonian Institution, Washington, DC. Obtainable from: Superintendent of Documents, US Government Printing Office, Washington 25, DC.
Smithsonian Rep. (USA)	Smithsonian Report Smithsonian Institution, Washington, DC. Obtainable from: Superintendent of Documents, US Government Printing Office, Washington 25, DC.
Trans Brit. Ceram. Soc.	Transactions of the British Ceramic Society Federation House, Station Road, Stoke-on-Trent, Staffordshire, England.
Uspekhi mat. Nauk (USSR)	Uspekhi Matematicheskikh Nauk Agent: Mezhdunarodnaya Kniga, Moscow.

NEW JOURNALS

Dunsink Obs. Publ. (Ireland)	Dunsink Observatory Publications Dunsink Observatory, Co. Dublin. Publisher: Observatory of the School of Cosmic Physics, Institute for Advanced Studies, Dublin. Vol. 1, No. 1 received 1961.
Mitsubishi Denki Lab. Rep. (Japan)	Mitsubishi Denki Laboratory Reports Research Laboratory, Mitsubishi Electric Manufacturing Company, Amagasaki. Quarterly. Vol. 1, No. 1, dated January, 1960.
Nuclear Fusion (Internat.)	Nuclear Fusion (Fusion Nucleaire—Yadernÿĭ Sintez—Fusión Nuclear) Journal of Plasma Physics and Thermonuclear Fusion International Atomic Energy Agency, Kärntnerring 11, Wien I, Austria. Vol. 1, No. 1, dated September, 1960.

ERRATA

Abstr. 953 (1961) line 3: for "N.H.Harris" read "N.H.March".
Abstr. 3368 (1961) line 7: for "g/cm^{-2}" read "g/cm^{2}".
Abstr. 3539 (1961) line 8: insert "τ" before "$= 2 \rightarrow 1$".
Abstr. 4706 (1961) line 2: for "Uflyana" read "Uflyand".
Abstr. 5372 (1961) line 4: for "160-1" read "161".
Author Index (Jan., 1961): delete "Harris,N.H., 953"; insert "March,N.H., 953".

AUTHOR INDEX

Aarons,J., 6595
Abakarov,Dzh.I., 6247
Abeledo,C.R., 6307
Abels,J.C., 5294
Abel's,V.R., 6296
Abel'skii,Sh.Sh., 6121
Abernethy,L.L., 6499
Abramova,K.B., 5713
Acharya,A., 5745
Adirović,E.I., 6173
Adirovich,E.I., 6174
Aditya,P.K., 5778
Adrian,F.J., 6042
Afanas'eva,V.I., 6652
Agîrbiceanu,I., 5296, 5982
Agodi,A., 5880
Agostinelli,C., 5567
Agranovich,V.M., 6225
Agranovskaya,A.I., 6195
Aharoni,A., 6300
Ainslie,D.S., 5525
Akhiezer,I.A., 5236
Akiba,T., 5909
Akimov,I., 6060
Akimova,M.K., 5929
Albert,P.A., 6333
Albridge,R.G., 5862
Aleksandrov,I.V., 6427
Alessio,M., 5610
Aleixandre Campos,V., 5242
Alexander,G., 5903
Alferov,Zh.I., 6168
Alford,W.P., 5861
Alfvén,H., 5438, 5447
Aliev,V.I., 5140
Alire,R.M., 6228
Allaby,J.V., 5725
Allegri,L., 5610
Allen,J.E., 5454
Allen,L.C., 5965
Allen,M.A., 5441
Allen,W.A., 5293
Alperin,H.A., 6103
Alpher,R.A., 5548
Alväger,T., 5853, 5865
Alves,R.V., 5736
Amat,G., 5991
Amati,D., 5717-18
Ambler,E., 5859
Ammar,R.G., 5832
Amonenko,V.M., 6545
Amsel,G., 5615
Amson,J.C., 5116
Ananiades,C.S., 5795
Anantharaman,T.R., 6528
Anbar,M., 6577
Andersen,S.L., 5915
Anderson,E.E., 6372
Anderson,E.W., 5273
Anderson,P.W., 5391
Andrä,W., 6276
Andrade e Silva,J., 5214-15
Andreev,M., 6096
Andrew,E.R., 6430
Andrew,K.F., 6502
Andrews,E.H., 6479
Andrews,F., 5210
Andrews,F.C., 5211
Andrews,K.W., 6065
Ansel'm,A.I., 6083
Antsilevich,M.G., 6651
Apaev,B.A., 6456
Apalin,V.F., 5900
Apostolescu,S., 5954
Appel,J., 6077
Aptekar',I.L., 6532
Arafa,A.A., 6184
Arajs,S., 6259
Araki,H., 5632
Arbell,H., 6230
Arbman,E., 5870
Arcan,L., 6017
Archer,R.R., 5319
Argyle,B.E., 6275
Armstrong,J., 6432
Armstrong,N.H.K., 5432
Arndt,R., 5433
Arnowitt,R., 5192
Arns,R.G., 5866
Aron,J.C., 5648-52
Arp,H.C., 5159
Arrott,A., 6379
Arthur,P., Jr. 6272
Artsimovich,L.A[S]., 5949
Arzhanov,A.S., 5381
Asch,G., 6332
Aschenbrand,L., 6612
Aschenbrand,L.M., 6608-11
Ascoli,R., 5672-3, 5683
Ascoli-Bartoli,U., 5473
Ashmore,A., 5725
Asplund,I., 5863
Astakhov,A.V., 5669
Ata,H.O.K., 6528
Atanasiu,G., 5850, 6647
Athay,R.G., 5155
Atsarkin,V.A., 6153
Auerbach,L.B., 5702
Auffray,J.P., 5790
Auld,B.A., 5588, 6408
Authier,A., 6511
Austin,I.G., 6160
Austin,S.M., 5912
Avdeev,V.L., 6425
Axe,J.D., 6420
Aylmore,D.W., 5246
Aziz,E., 6679
Azuma,R.E., 5771

Babbitt,R.W., 6356
Babcock,H.W., 5149
Bady,I., 6396
Baglin,J.E.E., 5890-1
Bailey,V.A., 5147-8
Bakamjian,B., 5200
Balashov,D.B., 6685
Baldeschwieler,J.D., 6044
Baldo-Ceolin,M., 5930
Balescu,R., 5205, 5449
Ball,M., 6365
Ballam,J., 5741
Baltensperger,W., 6252
Balȳgin,I.E., 6187
Banbury,P.C., 6146
Banks,E., 6350
Baqi Bég,M.A., 5776
Baraff,G.A., 5960
Baran,W., 6343
Baranov,A.I., 6468
Barbetta,M.G., 5804
Bardeen,J., 5395
Bardsley,W., 6136
Barducci,I., 6448, 6667
Bargmann,V., 5695
Barkemeyer,H., 6181
Barker,R.C., 6302
Barker,R.S., 6119
Barlow,A.J., 5277
Barnard,A.C.L., 5914
Barnes,G.A., 6146
Barr,E.S., 5179
Barr,N.F., 5707
Barrow,R.F., 6003
Bartenev,G.M., 6466
Bartley,S.H., 6669
Barton,G., 5681
Barton,J.C., 5809
Baruch,P., 5615
Bas,E.B., 5301
Bashkin,S., 5914
Bass,R., 5921
Bassi,A., 6485
Batchelor,R., 5734
Bate,G., 6310
Batty,C.J., 5902
Baum,E., 6571
Baumann,K., 5747
Baumgardt,E., 6681
Bayley,R.T., 6227
Beal,J.B., Jr, 6007
Beard,D.B., 5138
Bechert,K., 5638
Beckel,C.L., 5993-4
Beckurts,K.H., 5920
Bekeshko,N.A., 6429
Beliaev,S.T., 5234
Bell,G.D., 5976
Bell,J.D., 6632
Bell,J.F., 6457
Bell,R.E., 5879
Bella,F., 5609-10
Belov,N.V., 6507
Belov,S.P., 5703
Belson,H.S., 6400
Beltrametti,E.G., 5916-17
Belyaeva,B.A., 5479
Belyakov,Yu.I., 6114
Bendler,H.A., 6476
Benedek,G.B., 6432
Ben-Sir,M.Y., 6145
Berencz,F., 5980
Berestetsky,V.B., 5665
Berezin,A.B., 5479, 5481
Berezin,O.A., 5540
Berg,B.A., 6439
Berger,M.A., 6517
Bergman,R.S., 6409
Bergstrom,B.H., 6473
Bergström,I., 5855
Berinde,A., 5735
Berkes,I., 5896
Berlovich,E.Ye., 5852
Berman,S.M., 5749
Bernal,J.D., 6554
Bernardini,G., 5702
Bernas,R., 5984
Bershader,D., 5475
Bertanza,L., 5765
Bertinchamps,A., 6129
Bertocchi,L., 5674
Beşliu,C., 5735
Besnainou,S., 6032
Betts,R.H., 5926
Bhatnagar,C.S., 6198
Bhatnagar,P.L., 5537
Bhattacharyya,R.L., 5860
Bhawalkar,D.R., 6130
Bhide,V.G., 6503
Bhonsle,R.V., 6653
Bialynicki-Birula,I., 5635
Biasutti,M., 5716
Biener,M., 5817
Biermann,L., 5150
Bierstedt,P.E., 6375
Bies,D.A., 5330
Bigg,P.H., 5298
Bijvoet,J., 6298
Bimschas,G., 5493
Bindels,J., 6298
Biot,A., 6668
Bir,G.L., 6097
Bîrcă-Gălăţeanu,D., 6017
Birge,R.W., 5788
Birkenbeil,H.J., 6280
Birks,J.B., 5413-14
Birks,L.S., 6219
Bishop,J., 5986
Biswas,M M., 5745
Bither,T.A., 6374
Bittel,H., 5417
Bjorklund,W.R., 5312
Blackman,M., 6516
Bland,D.R., 6460
Blank,J.M., 6549
Blankenbecler,R., 5670
Blankenship,J.L., 5616
Blatt,J., 5826
Blatt,J.M., 5793
Blatt,S.L., 5612
Bleaney,B., 6426
Bleuler,K., 5817
Bloch,C., 5230
Bloembergen,N., 5285
Blokhintsev,D.I., 5767
Blokhintsev,L.B., 5929
Bloomfield,P., 6066
Blume,R.J., 6433
Boas,M.L., 5188
Bobrov,M.S., 6646
Bobȳl,V.G., 5280
Boccaletti,D., 5752
Bodmann,H.W., 6680
Boekelheide,I.F., 5612
Böer,K.W., 6079, 6176
Bogatȳrev,A.N., 6241
Bøggild,J.K., 5778
Boksha,S.S., 6686
Boland,J.W., 5168
Bölger,B., 6414
Bollinger,L.M., 5927
Bolt,B.A., 5135
Bonacalza,E.C.O., 5855
Bonalumi,R., 5729, 5732
Bonch-Bruevich,V.L. 6085-6, 6091
Bonera,G., 6580
Bonner,T.W., 5921, 5947
Bonsack,W.K., 5160
Bonsignori,F., 5759
Bonstrom,D.B., 6281
Boot,H.A.H., 5311
Bopp,G.R., 5312
Borisov,M., 6096
Borowitz,S., 5960
Bortolani,V., 5759
Bosgra,S.J., 5774
Bosman,A.J., 6118, 6546
Bossolasco,M., 6618
Bots,G.J.C., 5386-7, 5393
Bottino,A., 5683
Bouwknegt,A., 5580
Bowcock,J., 5764
Bowers,V.A., 6042
Bowhill,S.A., 6607
Bowles,K.L., 6613
Boyd,E.L., 6433
Boyle,A.J.F., 5831, 6273
Boynton,R.M., 6671, 6675
Braams,C.M., 5506
Bradbury,A., 6430
Brakhan,É.V., 6241
Brandt,J.C., 5158
Brar,S.S., 6596
Bratina,W.J., 6335
Bratož,S., 6032
Breene,R.G., Jr, 5963
Brekhovskikh,L.M., 5327
Brene,N., 5779
Breuer,W., 6343
Brient,S.J., 5969
Brigman,G.H., 5969
Brigoli,B., 5363
Brillouin,L., 5207
Brini,D., 5119
Brisson,J.C., 5770
Broberg,K.B., 6475
Brodin,M.S., 6202
Broer,L.J.F., 5535, 5562,
Broida,H.P., 6221
Brommer,P.E., 6118, 65
Brophy,V.A., 6500
Brose,M., 5920
Broude,C., 5914
Brout,R., 6265
Brown,M.G., 6028
Brown,N., 6535
Brown,W.F., Jr, 6301, 63
Brownell,R.M., 6302
Brú,L., 6512
Brucker,G.J., 5402
Brugger,R.M., 5737
Bruijn,P.J., 5376
Brune,J., 6585
Bruner,L.J., 6433
Bruschetti,S., 5732
Bruschi,C., 5732
Bryngdahl,O., 6676
Buchta,J.W., 5181
Bucur,I., 6647
Buczkó,M., 5608
Budagov,Yu.A., 5766
Budini,P., 5423
Budnick,J.I., 6433
Buehler,E., 5399
Buffler,C.R., 6387
Buhrow,J., 6222
Buishvili,L.L., 6424
Bukhvostova,N.G., 6359
Bunbury,D.S.P., 5831, 62
Bunt,B.P., 5245
Burch,J.M., 5353
Burcham,W.E., 5828
Bureau,A.J., 5516
Burger,E., 5523
Burger,J.P., 6257
Burgers,J.M , 5452
Burley,D.M., 6378
Burstein,E., 5400
Burton,M., 5279
Burtsev,V.A., 5478
Busch,G., 6253
Butler,J.W., 5313
Butler,R.A., 6664
Button,J., 5727
Bȳkov,V.N., 6115-16
Bȳkov,V.P., 5586
Byram,E.T., 6629

Cabannes,H., 5569
Cabibbo,N., 5777
Cable,J.W., 6347-8
Cabrera,N., 6489
Caforio,A., 5780
Cagniard,L., 6650

nodo,M.de P., 5780
n,R.W., 6280
aniello,E.R., 5653, 5658
laby,D.R., 6368
len,E.R., 6274
len,H.B., 6398
vert,J.M., 5932, 5934
neron,J.A., 5820
npbell,R.B., 6288, 6525
nplan,J., 5984
npolattaro,A., 5653
lan,H.S., 5409
elli,A., 5250
eri,G., 5389-90
leton,H.R., 5331
r,W.J.,Jr, 6333
rara,R., 5765
ver,J.H., 5898
sanova,G., 6067
sey,J., 6595
tañs Camargo,M., 5213
telli,J.P., 6595
alina,F., 6521
vanaugh,J.R., 6048-9
olin,C., 5674
rulus,F., 5740
krabarti,A., 5640
mberlain,J.W., 5157, 6628, 6639
mbers,R.H., 6446
mpeney,D.C., 5827
mpion,K.W., 6603
mpness,C.H., 6159
n Hong-Mo, 5217
ndrasekharan,V., 6442
ndratreya,V.M., 6503
ng,H., 5529
ng,I.Y., 6015
pman,S., 5185, 6604, 6654
rpak,G., 5742
shchina,G.I., 5480
tterjee,B.K., 5805
en,C.W., 6523
en Yung Yi, 5786
ernov,A.A., 6496
ernov,N.N., 5515
etroiu,A., 5982
ew,G.F., 5760
arotti,A.R., 6104
kazumi,S., 6318
lashvili,G.A., 5818, 5856
odi,L., 6580
uderi,C., 5754
ong,P., 5437
risty,R.F., 5882
risty,R.W., 6185
bb,T.A., 6629
dakov,A.E., 5797
dley,C.T., 5271
ltem,D., 5988
ynoweth,A.C., 6134
dor,P.E., 5352
ffolotti,L., 5916
lli,S., 5485
rebrough,L.M., 6453
rk,C.B., 5182
rk,J.W., 5886
rke,F.J.J., 6682
veland,F.F., 6000
ne,J.E., 5877
ud,W.H., 6374
wes,M.B., 6683
tes,R.J., 5169
hran,E.L., 6042
nsgen,F.H., 5467
a,H., 6410-11
hill,H.D., 6560

Cohen,A.V., 5905
Cohen,E.G., 5269
Cohen,L., 5794
Cohen,M., 5966
Cohen,M.H., 6550
Colburn,C.B., 6054
Cole,K.D., 5156
Coleman,B.L., 5190
Coleman,R.F., 5943
Coles,B.R., 6379, 6383
Colgate,S.A., 5547
Collins,C., 6606
Colombino,P., 5715
Colvin,R.V., 6259
Comaniciu,N., 5296
Comeford,J.J., 6213
Comşa,G., 5403, 5488
Comstock,R.L., 6408
Conder,P.C., 5311
Conn,J.B., 6186
Connes,P., 5354
Connor,D.W., 5923
Constantinescu,F., 6361
Coogan,C.K., 6437
Cook,J.R., 5872
Cookson,J.A., 5905
Cooper,B.F.C., 5578
Cooper,R.W., 6364
Coote,G.E., 5892
Copan,T.P., 6502
Corciovei,A., 5833, 6384
Coremans,M.J.F.J., 5386-7
Coren,R.L., 6329
Cormia,R.L., 5272
Cornet,N., 6129
Corsetti,C., 6485
Cortesi,C., 5609
Cosslett,V.E., 6659
Coté,R.E., 5927
Cottingham,N., 5764
Coulson,K.L., 6587-8
Coulter,J.R.M., 5432
Cox,A., 5132
Cox,N.L., 6272
Crittenden,R.R., 5741
Croft,W.J., 6351
Croll,I.M., 6285
Crosby,G.A., 6228
Csikai,J., 5608
Csongor,E., 5842
Cucurezeanu,I., 5998
Cuff,K.F., 6162
Cuffey,J., 5163
Culvahouse,J.W., 6260
Cummins,W.F., 5467
Cunnell,F.A., 6111
Cunningham,J.R.,Jr, 6372
Curtis,H.J., 5173
Cuzzocrea,P., 5925

Dąbrowski,J., 5814,5901
Dachs,J., 5126
Dahl,O.I., 5781
Dahler,J.S., 5269
Dailey,B.P., 6048-9
Dalgarno,A., 5966
Dallaporta,N., 5659
Danguy,G., 5619
Darden,S.E., 5911-12
Darnell,F.J., 6305-6, 6375
Das,A., 5629
Dasarathy,C., 6537-9
Datz,S., 6061
Dauenbaugh,C.E., 6157
Dautova,L.I., 6125
Davidge,R.W., 6483
Davidson,D.F., 5986
Davidson,E.R., 5999
Davis,D.H., 5782
Dayal,B., 6076

De Álfaro,V., 5676
de Andrés,M.P., 6128
De Angelis,A., 5473
Dearman,H.H., 6055
DeBenedetti,S., 5715, 6261
De Celles,P.C., 5776
De Dominicis,C., 5229
Deery,R.F., 5743
Deetscreek,V.D., 6355
de Graaf,A.M., 6252
de Graaf,W., 5294
Degregori,I., 5715
De Haan,Y.M., 6514
Deirmendjian,D., 6627
Deka,G.C., 5930
Dekhtyar,Ya.I., 6095
de Lange,H.,Dzn, 6673
Delvaille,J., 5802
DeMars,G.A., 6419
DeMastry,J.A., 5952
Demeter,I., 5896
Demeur,M., 5881
Demichelis,F., 5821
Demildt,A., 5937
Denisov,N.G., 5600
Dente,M., 5255-6
Denton,M.J., 5264
Denton,R.T., 5582
dePackh,D.C., 5494
Depietri,C., 5804
Depireux,J., 6129
Derado,I., 5698
Derrick,G., 5793
Deser,S., 5192
De-Shalit,A., 5822, 5835
De Socio,M., 5595
Detoeuf,J.F., 5770
De Tollis,B., 5887
Devanathan,V., 5751
Devare,H.G., 5829, 5868
Dévényi,A., 6561
Devlin,G.E., 6246
De Vries,C., 5495, 5873
Dewar,M.J.S., 6039
Dewdney,J.W., 5795
Diambrini,G., 5524
Dianov-Klokov,V.I., 5345
Dickerson,R.F., 5952
Diddens,A.N., 5725
Diikov,U.V., 5381
Dijkstra,J.H., 5873
Dillon,J.F.,Jr, 6406
Dinklage,J.B., 6337
Dir,G.L., 6142
Dixon,R.N., 6003
Dobrotin,N.A., 5801
Dobrovenskii,V.V., 5369
Dobrovol'skii,V.N., 6144
Doell,R.R., 5132
Doherty,R.H., 6592
Dolder,K., 5549
Dolecek,R.L., 6124
Dolgov-Savel'ey,G.G., 5462
Dolinsky,E.I., 5929
Domb,C., 6264
Dombey,N., 5761
Donoghue,T.R., 5911
Dorman,F.H., 6029
Dørum,O., 5915
Dourgnon,J., 5337
Dowell,J.D., 5724
Dowell,L.G., 6518
Dracott,E.D., 5472
Drăgănescu,V., 5982
Drago,A., 5765
Dreeskamp,H., 5279
Dressler,K., 6010
Dreyfus,R.W., 6189
Drickamer,H.G., 5348, 6206

Dropkin,J.J., 6182
Dubinskaya,N., 5701
Dubovoi,L.V., 5486
Dubois,J., 5844
Duchesne,J., 6129
Ducros,G., 5410
Dumitrescu,R., 5412
Dumont,R., 5122
Dunaitzev,A.F., 5773
Duncan,A.B.F., 6024
Duncan,R.A., 6638
Dungey,J.W., 6635
Dutt,I., 5860
Dwight,K., 6349
D'yakov,G.P., 6331
Dymanus,A., 5580, 6395
Dzhelepov,V.P., 5766
Dzhorbenadze,N.P., 5538
Dziwoki,A., 5972

Eades,J., 5725
Eades,R.G., 6430
Eason,G., 6459
Easton,W.B., 6149
Eastwood,E., 6632
Eastwood,H.K., 5820
Eberhard,P., 5727, 5788
Eberle,E., 5880
Eccleshall,D., 5841
Eckardt,A., 5523
Ecker,G., 5434
Economou,N.A., 5359-60
Eden,R.J., 5680
Eder,G., 5719
Edwards,C., 5831, 6273
Edwards,S.F., 5688
Efremov,A.V., 5679
Egardt,L., 5779
Eggers,F.G., 5577
Egorov,K.E., 5238
Egorov,L.B., 5988
Ehrenson,S., 6038
Eijkelenboom,L.C.H., 6118
Eisner,E., 6481
Éknadiosyants,O.K., 6578
Ekspong,A.G., 5728
Elbek,B., 5908
Elbinger,G., 6494
Eldridge,D.F., 6313
Eldridge,J.S., 5878
Elena,A., 6618
Elford,W.G., 6605
Elinson,M.I., 5490
Ellet,M.R., 6162
Elliott,R.J., 5271
Ellis,G.R.A., 6591
Elton,L.R.B., 5918
Elwell,D., 6436
Ely,R., 5788
Emeleus,K.G., 5432
Engelhardt,H., 5620
Englefield,M.J., 5785
Enz,C.P., 5197
Enz,U., 6251
Epstein,D.J., 6366
Eremenko,V.V., 6175
Erkamov,A.E., 5487
Ershov,A.G., 5517
Evans,D., 5930
Evans,H.C., 5373
Evdokomiv,V.D., 6465
Evtushenko,V.A., 5327
Ewan,G.T., 5840
Ewing,M., 6585
Eyges,L., 5202
Eykelenboom,L.C.H., 6546

Fahlenbrach,H., 6343
Falaleev,G.A., 6359
Falk,R.B., 6354

Falk-Vairant,P., 5770
Fano,G., 5689
Farley,F.J.M., 5742
Farnsworth,H.E., 6563
Fateev,A.P., 5522
Favella,L., 5697
Fedeli,R.P., 5804
Federbush,P., 5641
Fedorova,G.A., 6178
Feely,H.W., 6597
Feldman,S., 5262
Feltham,P., 6463
Fendley,J.R.,Jr. 5302
Fer,F., 5214-5
Ferguson,E.E., 6015
Ferilli,A., 5780
Ferioli,C., 6595
Fernandez,C., 6664
Ferrari,E., 5777
Ferraro,D., 5780
Ferraro,V.C.A., 6624, 6655
Ferro-Luzzi,M., 5722
Fidecaro,M., 5518
Fieschi,R., 6067
Figuera,A.S., 5524
Filosofo,I., 5702
Filov,R.A., 5944
Fine,M.E., 6163
Finkel'shtein,B.N., 6540
Finn,C.B.P., 6423
Finn,E.J., 5994
Fiorani,M., 5284, 6529
Fireman,E.L., 5142
Fisher,I.Z., 5219, 5268
Fishman,F.J., 5453
Fistul',V.I., 6141
Flanders,P.J., 6542
Fleischmann,H., 5938
Flippen,R.B., 6258
Fodor,I., 5896
Follenius,M., 6495
Fonda,L., 5675
Foner,S., 6412
Fonton,S.S., 6292
Forkman,B., 5895-7
Forrest,W.W., 5299, 5371
Forrester,J.D., 6510
Forster,K.E., 5375
Foster,H., 5311
Fournier,H., 6649
Fowler,C.A.,Jr. 6303
Fowler,G.N., 5857
Fowler,P.H., 5803
Fowler,W.B., 5788
Frackiewicz,B., 6366
Fradkov,A.B., 5384
Fraenkel,G.K., 6041
Fraga,S., 6036
Francis,G.W., 6237
Francombe,M.H., 6324
Franklin,R.N., 5499
Franzini,P., 5765
Fraser,M.J., 5380, 6559
Fray,S.J., 6212
Freeman,A.J., 6269
Freiberg,E., 5819
French,J.B., 5861
Frenkin,A.R., 5654
Fresa,A., 5137
Freund,P.G.O., 5747
Fricke,H., 5274
Fridkin,V.M., 6241
Fried,H.M., 5686
Friedberg,S.A., 6258, 6385
Friedlander,E.M., 5758
Friedman,H., 6629
Friedrichs,K.O., 5469
Frieman,E., 5563
Fries,R.J., 6515

Frisch,H.L., 5220
Frishman,I.G., 6634
Frisk,Å., 5728
Frisken,W.R., 5724
Frohlich,H., 5606, 5622
Frost,V.A., 5291
Fryer,E.M., 6303
Fujii,K., 5666
Fujiwara,Y., 6056
Fukuda,N., 5218
Fulford,J.A., 6006
Fuller,D., 6112
Fuller,H.W., 6326
Furth,H.P., 5547
Furui,S., 5666
Furukawa,M., 6581

Gabathuler,E., 5771
Gabovich,M.D., 5470
Gabriel,A.H., 5476
Gaebler,J.F., 5808
Gaiduk,V.I., 5626
Gailloud,M., 5716
Gale,N.H., 5932, 5939, 5941
Galitsky,V.M., 5232
Galkin,A.A., 6416
Galkin,G.N., 6152
Galperin,G.I., 6637
Gandía,V., 5278
Gandolfi,A., 5119
Ganneev,A.S., 6220
Ganguly,A.K., 5924
Gans,P., 5696
Ganz,D., 6339
Gardner,E.L., 5956
Gardner,J.W., 5460
Gardner,L.B., 5611
Garg,J.B., 5932, 5939, 5941
Garland,C.W., 6075
Garmire,G., 6641
Garrison,G.R., 5328
Garton,G., 6365
Garwin,R.L., 5742
Gáspár,R., 6084
Gat,J.R., 5846
Gatti,G., 5518
Gautvik,E., 5915
Gebbie,H.A., 6160
Geffen,D.A., 5749
Geiger,J.S., 5840
Gelberg,A., 5403, 5488
Gell-Mann,M., 5700
Georgescu,A.,5403
Germain,P., 5568
Gerstner,D., 6336
Geschwind,S., 6362
Ghita,C., 5282
Ghosh,S., 5745
Giacomelli,G., 5518
Giannelli,G., 5411
Gianola U.F., 5530
Gilat,J., 5846
Gilbert,N., 5906
Gilboy,W.B., 5734
Gill,J.S., 5334
Gillett,F., 5152
Gilman,J.J., 6477
Gilvarry,J.J., 6472-3, 6642
Ginell,R., 5270
Gingrich,N.S., 5266
Ginzburg,V.L., 6193
Girardeau,M., 5222
Giurgea,M., 5282
Gladushtak,B.I., 5479
Glaister,R.M., 6486
Glang,R., 6149
Glashow,S.L., 5664, 5787
Glasko,V.B., 6085
Glasov,O.A., 5486
Glassgold,A.E., 5235
Glazer,A.A., 6533
Glentworth,P., 5926
Gliddon,J.E.C., 6624
Goland,A.N., 6544
Gold,A., 5959
Gold,A.V., 6070
Goldberg,N., 6400
Goldemberg,J., 5889
Golding,R.M., 6025
Goldstone,J., 5690
Goldzahl,L., 5744
Golikov,E.E., 6660
Golyamina,I.P., 5323
González Ibeas,J., 5242
Gooch,C.H., 6111
Good,M.L., 5788
Gorbunov,E.P., 5462
Gorbunov,V.I., 6532
Gorchakov,E.V., 5797
Gordeev,G.V., 6168
Gordon,A.S., 6570
Gordov,A.N., 5381
Gorelik,L.L., 5474
Gorelik,S.S., 6106
Gorshkov,G.V., 5705
Gorter,C.J., 5393
Goryachev,Yu.M., 5511
Gossard,E.E., 6594
Goudmand,P., 6057
Gould,J.H., 6213
Gourdin,M., 5753, 5789
Grabari,V., 5403
Grad,H., 5556
Graham,C.D., Jr, 6319
Graham,R.L., 5840
Gran,B.E., 6321
Graneau,P., 5532
Grant,N.J., 6470
Gratot,I., 5913
Gray,W.A., 6552
Green,J.J., 6399, 6402
Green,T.S., 5466
Greener,E.H., 6163
Greenstein,J.L., 5171
Gregory,A.G., 5910, 5935
Greifer,A.P., 6369
Greiner,C., 6297
Greiner,J.H., 6285
Greisen,K., 5802
Greuling,E., 5858
Gribov,V.N., 5667
Gridnev,K.A., 6238
Griffiths,D., 6383
Grigor'ev,A.M., 5248, 5305
Grigoriev,E.P., 5874
Grigoriu,A., 5513
Grinberg,G.A., 5114, 5539, 5593
Gringauz,K.I., 6644
Gross,B., 5712
Grossetti,E., 5253
Groth,W.E., 6575-6
Grunberg,L., 6564
Gschwendtner,K., 6331
Gualdi,C., 5752
Gubkin,A., 6199
Guenebaut,H., 6057
Guerriero,L., 5780
Guest,P.G., 5405
Guggenheimer,K.M., 5721
Gulbransen,E.A., 6502
Gunnersen,E.M., 5792
Gupta,R.C., 6191
Gupta,R.K., 5829
Gupta,V., 5662
Gurevich,V.M., 6194
Gustafson,P.F., 6596
Gutmann,J.R., 5846
Gutowsky,H.S., 6437
Guttman,L , 6536
Guttmann,S., 6577
Gyorgy,E.M., 6367

Haag,R., 5632
Haake,C.H., 6224
Haas,C.W., 6398
Haas,F.A., 5443
Hack,M.N., 5958
Hacman,D., 5315
Haenni,H.P., 5921
Hagedorn,F.B., 6367
Hahn,E.L., 6421
Haidemenakis,E., 6181
Hain,K., 5484
Halbert,M.L., 5616
Hall,H.E., 5831
Hall,I.H., 6469
Hall,J.M., 6657
Häller,I.B., 5870
Halliday,F.O., 5547
Halperin,A., 6230
Hamakawa,Y., 6165
Hameka,H.F., 5967
Hamermesh,M., 5958
Hamilton,C.W., 5426
Hamilton,J.H., 5875
Hamilton,J.R., 5983
Hammer,C.L., 5516
Hands,R.A., 5343
Handy,W.A., 6434
Haneman,D., 6146
Hanna,S.S., 5838
Hansen,K.H., 5778
Hanson,A.O., 5702
Harang,L., 6614
Hardy,J.R., 6211
Hargreaves,M.E., 6453
Hariharan,P., 5339, 5351
Harper,P.G., 5396
Harris,I., 5176, 6601
Harrison,S.E., 6520
Harrison,W.A., 6087
Hart,J., 5414
Hartl,W., 6094
Hartland,A., 5287
Hartmann,E., 6504
Hartwick,T.S., 6407
Harvey,J.S., 6531
Hashmi,S.Z.R., 5362
Hasimoto,H., 5559
Hasted,J.B., 5981
Hauser,I., 5620
Hayess,E., 5471
Hayward,A.T.J., 5416
Hayward,R.W., 5859
Hazen,W.E., 5808
Heath,R.L., 5877
Heaton,L., 5266
Hecht,K.T., 6001-2
Hefley,G., 6592
Heflinger,L.O., 5464
Heiz,R., 5316
Helfand,E., 5220
Helfer,H., 5755
Heller,G.S., 6381
Heller,W., 5359-60
Helliwell,T.M., 5970
Helmers,K., 5834
Hemstreet,R.A., 5983
Hendel,A.Z., 5808
Henderson,W.D., 6007
Henin,F., 5205, 5210
Henry,L., 5991
Henry,P.P., 5309
Hentschel,H.J., 5335
Herbert,D.N., 5943
Herdan,R., 5450
Hernáez,J., 6530
Herschbach,D.R., 6064
Herzberg,G., 6052
Heslop,W.A., 5343
Hexter,R.M., 6010, 6214
Hicks,B.L., 5261
Hide,R., 5549, 5552
Higdon,W.T., 6579
Hight,M.J., 6403-4
Hight,R., Jr, 6579
Hill,R.D., 5782
Hill,R.M., 6409
Hiller,C., 5349
Hilton,A.R., Jr, 6007
Hirschfelder,J.O., 6567
Hjalmar,E., 5933
Hoarau,J., 6254
Hodge,P.W., 5164
Hodgson,P.E., 5884, 5922
Hojvat,N.L., 6039
Hollander,J.M., 5862
Holló,M.G., 6491
Holmen,J.O., 6321
Holmes,M.F., 6183
Holte,J.E., 5325
Holtebekk,T., 5915
Holzapfel,L., 6227
Hook,J.F., 5321
Hooper,G.D., 6354
Hooper,J.E., 5778
Hopkins,T.E., 6293
Hoppes,D.D., 5859
Horn,G., 5406
Hornback,C.E., 5914
Hornstra,J., 6109
Horwitz,N., 5781
Hoselitz,K., 6250
Hotston,E.S., 5415
Hough,P.V.C., 5618
House,L.L., 5155
Houtgast,J., 5151
Howard,W.M., 5290
Howell,V.T.S., 5476
Hoyaux,M., 5696
Hsu,F.S.L., 5399
Huang,K., 5225
Hubbard,J., 5446
Huch,W.F., 5152
Hugenholtz,N.M., 5221
Huggins,C.M., 5273
Hughes,J.E., 6171
Hughes,R.H., 5975
Hultberg,S., 5875
Hultqvist,B., 6615
Hulubei,H., 5735
Hunt,R.P., 6366
Hurd,C.M., 5372
Hurwitz,H., Jr, 5548
Hutchison,C.A., Jr, 6234
Huxtable,G.B., 5725

Ibragimova,D.M., 6445
Ignatenko,A.E., 5746, 5988
Ikeda,M., 6671
Imaeda,Y., 6438
Imai,I., 5573
Ingalls,R., 6261
Ingraham,J.N., 6272
Inn,E.C.Y., 6021
Inoue,N., 5823
Ioffe,A.F., 6137
Ionov,N.I., 6114
Iosifescu,B., 5488
Isaev,P.S., 5768
Ishida,S., 5504
Ishiguro,K., 5576
Ishii,Z., 6451
Ishikawa,M., 6621
Ismail-Zade,T.A., 5140
Isted,G.A., 6632
Isupov,V.A., 6195
Itô,D., 5666
Ito,K., 6046
Ivanov,D.P., 5463
Ivascu,M., 5735
Iveronova,V.I., 6541
Iwata,K., 5666
Izrailev,I.M., 6220
Izyumov,Yu.A., 6391

Jaccarino,V., 6262, 6431
Jache,W., 6007
Jackson,H.E., 5927
Jacobs,I.S., 6255, 6380
Jacobsohn,B.A., 5231
Jacoodine,R.J., 6505
Jaeckel,R., 5300
Jaeger,J.C., 5113
Jaffe,H., 6444
James,A.N., 5936
James,G., 5792
Janik,J., 5730
Janik,J.A., 5730
Janssen,K., 6343
Janssen,T.W.J.M., 5206
Jarrett,H.S., 6375
Jaśkiewicz,A., 6196
Jastrow,R., 5176, 6601
Jauch,J.M., 5194
Jech,A., 5855
Jefferies,J.T., 5154
Jefferson,C.F., 6373
Jeffery,J.W., 5118
Jeffries,C.D., 6420
Jelley,J.V., 5798
Jellinghaus,W., 6128
Jelly,D.H., 6606
Jenks,G.J., 6430
Jensen,E.N., 5847
Jepson,W.B., 5246
Jeszenszky,B., 6504
Jha,S., 5829, 5868
Johansson,P., 6088, 621
Johansson,S.A.E., 5825
Johnson,A.A., 6454
Johnson,C.E., 6312
Johnson,F.A., 6054, 6212
Johnson,F.S., 5131
Johnson,P.D., 6200
Johnson,R.H., 5548
Jones,B.D., 5782
Jones,H.M., 5178
Jones,P.B., 5815
Jones,R.P.N., 5318
Jones,W.M., 6558
Jongejans,B., 5621
Jortner,J., 5275
Joseph,R.I., 6401
Joss,E.J., 5117
Jouvet,B., 5744
Julien,C.A., 5288, 6525
Jungclaus,G., 5555
Juretschke,H.J., 6329
Jursa,A.S., 6021, 6586

Kabemoto,S., 6105
Kadomtsev,B.B., 5458
Kadota,N., 5504
Kaeser,R.S., 5859
Kageyama,S., 5288
Kalashnikov,S.G., 6147
Kalbfleisch,G.R., 5727
Källen,G., 5196
Kallmann,H., 6181
Kalman,G., 5440
Kalmÿkova,S.S., 5585
Kamal,A.A., 5783
Kamefuchi,S., 5633
Kameswara Rao,K.V., 5342

Kaminisi,K., 5161
Kaminow,I.P., 6395
Kantor,P.B., 6074
Kantrowitz,A., 5453
Kapany,N.S., 5340
Kaplan,A., 5531
Kaplan,S.A., 5561
Kaplan,T.A., 6349
Kaplun,V.A., 5592
Karlikov,V.P., 5289, 5542
Karp,S.N., 5357
Karr,H.J., 5465
Kashkai,M.A., 5140
Katul,J., 6090
Katz,A., 5826
Kaufmann,L., 6531
Kay,E., 6325
Kay,H.F., 6486
Kay,R.M., 6290
Kazanskii,Yu.A., 5703
Kazantsev,A.N., 6625
Kazantsev,A.P., 5541
Keffer,F., 6266, 6413
Keller,J.B., 5357
Kellogg,P.J., 5152
Kellogg,W.W., 5172
Kelly,D.H., 6674
Kelsey,C.A., 5911
Kemeny,L.G., 5951
Kempis,E.B., 6557
Kempter,C.P., 6515
Kemsley,D.S., 6464
Kenan,R.P., 6377
Kendall,P.C., 6624
Kendziorski,F., 5802
Kerrigan,M.A., 6596
Keszthelyi,L., 5896
Kevane,C.J., 5128
Khabibullin,B.M., 6345
Khaldin,N.N., 5512
Khan,I.H., 6516
Khanna,S.M., 6130
Khansevarov,R.Yu., 6177
Khavkin,L.P., 5248
Khlebnikov,G.I., 5944
Khodov,Z.L., 5276
Kholodar',G.A., 6205
Khozov,G.V., 6166
Kichigin,D.A., 6416
Kihara,T., 5448
Kimura,M., 5909
King,G.A.M, 6631
King,H.J., 5820
King,I., 5162
King,J.H., 6160
King,R.B., 5976
Kino,G.S., 5441
Kino,T., 6105
Kirillov,D.D., 5463
Kirkland,P.C., 5328
Kisel',A.N., 6074
Kistiakowsky,G.B., 6568-9
Kleen,R.H., 5603
Klem,L., 6666
Klementyev,V.N., 5852
Klier,E., 6179
Kline,R.K., 6505
Klinkenberg,P.F.A., 5971
Klots,C.E., 6568-9
Klotsman,S.M., 6113
Klumpp,R.G., 6661
Klyuchnikov,Yu.F., 6125
Knapp,E.A., 5465
Kneale,S.G., 5333
Kneller,E., 6336
Knight,W.D., 5605
Knowles,J.E., 5527, 6360
Knox,F.B., 5461
Knudsen,E., 6593
Knyazeva,L.V., 5592
Kobelev,Ya.L., 6092
Kobuke,Y., 6226
Koch,L., 5614
Kochanova,L.A., 6471, 6478
Kodyukov,V.M., 5705
Koehler,W.C., 6346-8
Koh,P.K., 6527
Kohra,K., 6451
Kojima,Y., 6388
Kolb,A.C., 5468
Kolesnikova,E.N., 5593
Kolesnikova,M.M., 5687
Koller,L.R., 6560
Koloskova,N.G., 6428
Komar,A.A., 5989
Komar,A.P., 5515, 5706 5709, 5893, 5989
Komar,E.G., 5477
Komel'kov,V.S., 5430
Komnik,F.Yu., 5379
Kondorskiy,Ye.I., 6429
Konishi,T., 6664
Konopleva,R.F., 6166
Konwent,H., 6196
Kopaleishvili,T.I., 5818, 5856
Kopeliovich,B.L., 5268
Kopvillem,U.Kh., 6428
Korgueva,I., 5412
Korobeinikov,V.P., 5542
Korolev,F.A., 5517
Korostoff,E., 6322
Korringa,J., 6377
Koster,G.F., 6419
Kotelnikov,K.A., 5801
Kotlyar,B.I., 6218
Kouvel,J.S., 6255, 6279
Kovarzh,Z., 5706
Kovásznay,L.S.G., 5451
Kovtun,S.F., 6545
Kozlov,A.A., 6331
Kraft,R.P., 5159
Kramer,B., 6181
Kramers,H.C., 5388
Krasnoperov,G.V., 6270
Krasnov,L.V., 5852
Krasovitskaya,R.M., 6074
Krasovskii,Yu.P. 5259
Krassovsky,V.I., 6600
Krauss,M., 5418
Krecker,U., 5620
Kreger,W.E., 5869
Kreimer,G.S., 6468
Kriessman,C.J., 6520
Krishnan,A.A., 6522
Krishnan,R.S., 6442
Krivoglaz,M.A., 6524
Krochmann,J., 5361
Krolikowski,W., 5644
Kromer,H., 6132
Kromminga,A.J., 5904
Kronenberg,K.J., 6526
Krook,M., 5295
Kruglov,S.P., 5709
Krzywicki,A., 5646
Ku,T.C., 5489
Kubo,M., 6046
Küchle,M., 5733
Kuglin,C.D., 6162
Kukin,V.D., 5654
Kulikov,O.F., 5517
Kulikovski,A.G., 5570
Kumar,D., 6436
Kumar;R.C., 5655
Kümmel,H., 5691
Kunzler,J.E., 5399
Kuo,J., 6585
Kupperian,J.E, Jr, 6629
Kurath,D., 5836
Kurbatov,L.V., 6390
Kuri,Z., 6056
Kurilko,V.I., 5455
Kuriyama,K., 5909
Kurochkin,S.S., 5519, 5526
Kuroda,K., 5909
Kuropatenko,V.F., 5292
Kusch,P., 6051
Kushida,T., 6226
Kushul',M.Ya. 5244
Kutikov,I.Ye. 5900
Kuznetsov,A.S., 5755
Kuznetsov,N.M., 5430

Laboragine,L., 5780
Lăbuşcă,E., 6361
Ladenbauer,I.M., 5942
Lagasse,J., 5404
Lagerqvist,A., 6003
Lagnaux,J.P., 5782
Lamb,J., 5277
Lambert,R.F., 5325
Lämmermann,H., 6207
Landsberg,P.T., 6081
Lane,J.A., 5579
Lanenkina,V.K., 5431
Lang,G., 6261
Lang,I.G., 6083
Langenberg,D.N., 5400
Lannutti,J.E., 5727
Lanzi,G., 6580
La Paglia,S.R., 6024
Lapkin,N.I., 6270, 6359
Lardner,R.W., 5678
Larionov,B.A., 5477
Lasinio,G.J., 5887
Latsh,V.V., 6487
Laughlin,J.S., 5707
Lavlinov,L.V., 6116
Lawrence,P.E., 6308
Lawson,A.W., 6066
Lawson,R.D., 5836
Lax,B., 6203
Leader,E., 5717-18
Leask,M.J.M., 6365
LeBlanc,F., 6586
LeBlanc,F.J., 6021
Lebowitz,J.L., 5220
Leckie,F., 5317
LeCraw,R.C., 6353
LeCroy,W., 5520
Lehiste,I., 6662
Lehmann,J., 6227
Lehmann,W.J., 6013-14
Lehnert,B., 5459, 5554
Leijzers Vis W., 5505
Lemaire,H.P., 6351
Leonard,S.L., 5464
Le Pape,M., 5913
Leruste,P., 5214-15
Leslie,C.B., 5326
Leslie,F.E., 6590
Lessoff,H., 6369
Levi Setti,R., 5832
Levin,B.Yu., 5134
Lewin,G., 5123
Lewis,G.M., 5771
Leyenaar,A., 6531
Li,J.C.M., 6108
Li Syuang-Ming, 5988
Libby,W.F., 5849
Liebson,M., 6687
Likhtman,V.I., 6471, 6478
Liley,B.S., 5450
Lim,T.G., 5774
Limentani,S., 5832
Lin,C.C., 5603
Lin,C.J., 6309
Lin,S.T., 6291
Lindgren,E.R., 5257-8
Lindner,J., 5638
Linfield,R.F., 6592
Liotta,R.S., 5887
Lipson,S.G., 5264
Lisitsa,M.P., 6205
Lissberger,P.H., 5310
Litovchenko,V.G., 6144, 6155
Littlefield,T.A., 5343
Liu Shun-fu, 6233
Livesey,J.L., 5251
Livshits,B.L., 5198
Livshits,L.D., 6685
Lobanov,Yu.N., 5521
Lobikov,E.A., 5474
Lochak,G., 5214-15
Logachev,J.L., 5797
Loh,E., 6215
Lommel,J.M., 6319
Longo,J., 6376
Loretto,M.H., 6453
Loshaek,S., 5281, 6236
Lostis,P., 5350
Loudon,L., 6266
Love,W.A., 5518
Lovera,G., 5804
Low,F.E., 5624
Łożykowski,H., 6239-40
Luborsky,F.E., 6308, 6341
Lucas,M.S.P., 6688
Luck,G., 5613
Ludford,G.S.S., 5574
Ludvigh,E., 6670
Lumbroso,N., 6254
Lupu,C., 6017
Luria,S.M., 6672
Lurié,D., 5753, 5764
Lushchik,Ch.B., 6131
Lüst,R., 5484
Luttinger,J.M., 6256
Lyashenko,V.S., 6115-16
Lykoudi,P.S., 5551
Lynch,G.J.E., 5601
Lynch,G.R., 5727
Lynn,R.L., 5869
Lyon,D.N., 6293
Lyon,W.S., 5878
Lyons,D., 6349
Lyu Shun'-fu, 6233
Lyubimov,G.A., 5570
Lyubin,V.M., 6178

McAleer,W.J., 6181
McCall,D.W., 5273
McCall,G., 6396
McCarthy,I.E., 5904
McConkey,E.A.G., 6119
McConnell,H.M., 6026, 605
McCree,K.J., 6677-8
McCullagh,G.C., 5482
McCune,J.E., 5557
McDonald,R.S., 5346
McIntosh,B.A., 5170
McIntosh,H.V., 6506
Macefield,B.E.F., 5940
Macfarlane,R.D., 5987
Mack,J.E., 5974
Mackenzie,J.D., 5346
McLean,T.P., 6210
McNesby,J.R., 6570, 6573
Macovei,M., 5513
Macrae,J.C., 6552
Madden,H.H., 6563
Madorskii,A.Ya. 6462
Maeda,H., 6658
Maeder,D.G., 5407
Maeva,S.V., 5134
Magistrelli,F., 5454
Maglić,B.C., 5727
Mahanty,J., 6069
Majumder,N.K., 5924
Mak,A.A., 5428
Makarov,S.S., 5327
Makhnovskii,E.D., 5893
Makhov,A.F., 6098
Maki,A.H., 6040
Makkink,J.H., 5505
Malhotra,P.K., 5800
Malinofsky,W.W., 6356
Malkin,G.M., 6192
Malville,J.M., 6640
Malyshev,G.M., 5479-81
Malyshev,I.F., 5477
Malyshev,V.A., 5303
Mamasakhlisov,V.I., 5818
Mandelstam,S., 5760
Mangum,B.W., 6234
Mannelli,L., 5765
Manring,E.R., 5141, 6612
March,P.V., 5894
Marchand,A., 6254
Marcinkowskii,M.J., 6535
Marcley,R.G., 5247
Marcu,M., 5758, 5799
Marcus,R.A., 6574
Maréchal,A., 5341
Margolis,B., 5731, 5785
Maringer,R.E., 6447
Markham,M.F., 5322
Marmo,F.F., 6608-12
Márquez,R., 6512
Marsh,H.W., 5332-3
Marshall,L., 5166
Martalogu,N., 5412, 5735
Martelli,G., 5724
Martellucci,S., 5473
Martin,A., 5753
Martin,J.H., 5710
Martin,M.B., 5866
Martius,U.M., 6335
Martz,D.E., 5347
Mashovets,T.V., 6148
Mason,J., 6554
Mastova,L.V., 6166
Masuda,I., 6226
Matcovich,T., 6322, 6400
Mathur,S.B., 6599
Mathur,V.S., 5714
Matlow,S.L., 6035
Matsen,F.A., 5969
Matusevich,E.S., 5703
Matuyama,E., 6566
Matveev,O.A., 6166
Maxwell,A., 6641
Mayer-Kuckuk,T., 5408
Mayrone,L., 5715
Mazel',E.Z., 6153
Męczyńska,H., 6240
Mednikov,A.K., 6147
Medvedev,V.S., 6175
Meiklejohn,W.H., 6278
Meissner,H.G., 6528
Melchior,M.T., 6040
Mel'nikov,M.A., 5427
Men',A.N., 6547-8
Mendoza,E., 5382
Menotti,P., 5699
Menyuk,N., 6349
Mercea,V., 6572
Merlin,M., 5780
Mescheryakov,M.G., 5755
Meshcheryakov,V.A., 5679
Messier,J., 5614
Methfessel,S., 6330
Metson,G.H., 6183
Metzger,F.R., 5876

Meyer,A,J.P., 6332
Meyer,P., 5784
Meyer,R.X., 5575
Meyerand,S.G., Jr, 5502
Michaelis,E.G., 5809
Michels,A., 5294
Micu,M., 5485, 5851
Middelhoek,S., 6330
Middelkoop,W.C., 5518
Middlehurst,J., 5366
Middleton,F.H., 6287
Midzuno,Y., 5448
Mikaelyan,L.A., 5900
Mikhailov,N.Ya., 6467
Mikhalenkov,V.S., 6095
Mikheev,G.F., 5515
Miles,J.W., 6584
Milevskii,L.S., 6151, 6154
Miller,D., 5373
Miller,D.H., 5781
Miller,H.C., 6305
Miller,J.W., 6670
Milligan,D.E., 6010
Mills,A.D., 6156
Mills,D., 6558
Mills,R.L., 6377
Minaev,N.G., 6487
Minguzzi,A., 5888
Minin,I.N., 5336
Minnhagen,L., 5964
Minzner,R.A., 6603
Mira,C., 5404
Mironov,E.S., 5512
Mirri,A.M., 6009
Mishra,U.C., 5848
Misner,C.W., 5192
Mitchell,E.W.J., 6146
Mitler,H.E., 5839
Mitra,A.P., 6599
Mitrofanova,S.S., 5431
Mitskevich,P.K., 5280
Miwa,H., 6268
Miya,K., 6621
Moak,C.D., 5500
Mohan,G., 5671
Moiseev,A.I., 6445
Molea,M., 5412
Molinari,A., 5683
Monfils,A., 6052
Monostori,B., 6019
Monoszon,N.A., 5477
Montaldi,E., 5645
Moon,P.B., 5827
Mooser,E., 6139
Moran,T.I., 5996
Morelock,C.R., 6501
Morgan,L.O., 5285
Morgan,P.G., 5252
Moroz,E.M., 5457
Morpurgo,G., 5754
Morris,J.R., II, 6037
Morrish,A.H., 6281
Morrison,J.D., 6029
Morrison,S.R., 6157
Morton,D.C., 5153
Moruzzi,V.L., 6252
Moshinsky,M., 5695
Moskalev,E.I., 5480
Moskalev,V.I., 5766
Moss,T.S., 6158
Moszkowski,S.A., 5813
Mukherjee,P.N., 5860
Mukherjee,S.K., 5924
Mukhovatov,V.S., 5462
Muller,G.M., 5710
Müller,K.G., 5306-7
Muller,M.W., 6387
Muller,T., 5742
Müller-Uri,G., 6582
Mulot,P., 5955

Munir,B.A., 5756
Murcray,D.G., 6590
Murcray,F.H., 6590
Murphy,S.R., 5328
Murphy,W.K., 5346
Murray,E.L., 5143
Murray,J.J., 5781
Murthy,G.T., 5805
Murty,G.S., 5543
Murzin,V.S., 5801
Musa,G., 5488
Musa,M., 5282
Musgrave,B., 5724
Musgrave,M.J.P., 5322
Mustard,D., 5793
Mutsuro,N., 5909

Nachman,M., 5739
Nagai,K., 6062-3
Nagai,R., 6480
Nagakura,M., 6357
Nakada,Y., 6369
Nakagawa,Y., 5364
Nakamura,H., 5643
Nambu,Y., 5670
Napolitano,L.G., 5550
Naqvi,M.A., 5688
Naranan,S., 5805
Narasimhan,P.T., 6047
Nardelli,G.F., 6104
Narten,A., 5985
Nayyar,N.K., 5543
Nazarov,N.I., 5487
Neale,R.N., 6657
Nechai,E.P., 6117
Neddermeyer,S.H., 5743
Nedospasov,A.V., 5422
Nelson,T.M., 6669
Nemenov,L.M., 5512
Nemilov,Yu.A., 6238
Nesbitt,E.A., 6382
Neştianu,T., 6647
Neuman,M., 5199
Newcomb,W.A., 5544
Newman,R., 6215
Nexsen,W.W., Jr, 5467
Ney,E.P., 5152
Nicholas,J.F., 6453
Nichols,R.T., 5847
Niculescu,D.Z., 5617
Nierhaus,R., 5408
Nigam,B.P., 5714
Nikitin,M.K., 5852
Nikol'skii,E.N., 5240
Nikol'skii,S.I., 5806
Nilsson,S., 5728
Nobe,K., 6571
Nordfors,B., 5711
Noreika,A.J., 6324
Norinder,H., 6593
Norinelli,A., 6583
Nosar',A.I., 6122
Notarrigo,S., 5925
Novik,A.E., 5422
Nozaki,T., 6581
Nuovo,M., 6448

Obenshain,F.E., 5830
Oberländer,S., 6082, 6176
Obukhovskii,V.V., 6462
O'Connor,D.A., 5738
O'Connor,T., 5875
Odenthal,D.W., 6665
Odian,A.C., 5702
Oehme,R., 5685
Okabe,H., 6573
Okamura,T., 6388
Okazaki,A., 5912
O'Keefe,J.A., 5144
Okubo,S., 5658, 5682

Olafson,R.A., 6018
Oldenberg,O., 6022
Oleari,L., 5284, 6529
Olesen,M.C., 5908
Olkowsky,J., 5913
Olsen,J.L., 5398
Olsen,K.H., 6286
Olte,A., 5145
Oncescu,M., 6127
Ondoh,T., 6658
Opechowski,W., 6508
Öpik,E.J., 5133
Oppegard,A.L., 6272, 6305
O'Raifeartaigh,L., 5628
Orbach,R., 6423
O'Reilly,J.M., 6008
Ortner,J., 6615
Orzhevskii,O.B., 6141
Osborne,D.W., 5370
Oselka,M., 5514
Osher,J.E., 5465
Osipenko,N.N., 6541
Oster,L., 5147
Ostrovskii,Yu.I., 5973
Ostrowski,J.W., 6164
Otter,M., 6201
Overend,J., 5990
Overmeyer,J., 6394
Ovrutskaya,R.M., 6218
Ovsienko,D.E., 6110
Owen,H.A., Jr, 6688
Owen,J., 6418

Pacault,A., 6354
Pace,J.H., 6422
Pack,J.L., 5420
Paetzold,H.K., 5174
Pai,S.I., 5483
Pais,A., 5660
Palatnik.L.S., 5379
Palfrey,T.R., Jr, 5757
Palmer,D.A., 5353
Palmer,D.R., 6157
Pande,D.N., 6229
Pandit,L.K., 5659
Panenkova,L.S., 6117
Pangonis,W.J., 5359-60
Pannetier,G., 6057
Pappas,A.C., 5854, 5946
Pappas,C.F., 5596
Parr,R.G., 5957
Parrent,G.B., Jr, 5358
Parry,G., 5796
Pasechnik,L.L., 5470
Passatore,G., 5899
Passell,T.O., 5254
Patȳ,L., 5304
Pavlik,N., 6344
Pavlinov,L.V., 6115
Pavlovskaya,V.S., 6540
Pawlek,F., 6284
Pearson,F.J., 5385
Pearson,J.E., 5579
Pearson,R.F., 6364, 6404
Pearson,W.B., 6070, 6139
Pederson,E.C.B., 5879
Peierls,R.E., 5180
Peiffer,H.R., 6123
Peletminskii,S.V., 5236
Penkin,N.P., 5973
Percival,I.C., 5216
Peregud,B.P., 5713
Peres,A., 5186, 5534
Peresada,V.P., 5591
Peressini,E.R., 6407
Perez,M., 5855
Perfilov,N.A., 5944-5
Perkin,J.L., 5943
Perkins,D.H., 5803
Perring,J.K., 5811

Perry,C.L., 5254
Pestel,E., 5317
Peter,M., 6417
Peterson,A.W., 5146
Peterson,G.E., 6662
Petrashku,M.G., 5988
Petrov,Yu.G., 5948
Petruska,J., 6030-1
Petrzhak,K.A., 5948
Petschek,H.E., 5453
Pettsol'd,É.G., 6242
Petty,E.R., 6484
Phelps,A.V., 5420
Phillip,K.W., 5147
Phillips,D.L., 5274
Phillips,R.J.N., 5769, 5811
Phillipson,P.E., 6038
Pickup,E., 5756
Pierce,L., 5995, 6008
Pierce,R.D., 6385
Pietri,G., 5492
Pikus,G.E., 6097, 6142
Pilar,F.L., 6037
Pilipovich,V.A., 6235
Pilyankevich,A.N., 5979
Pimbley,W.T., 5489
Pines,B.Ya., 6461, 6556
Pines,D., 6093
Pinkau,K., 5803
Pinski,G., 5762
Piotrowski,E.A., 6016
Piron,C., 5716
Pisarenko,V.F., 5327
Pisarevskii,A.N., 6238
Pistol'kors,A.A., 5592
Pizzella,G., 5722
Platt,J.R., 6004
Plebanski,J., 5686
Pliquett,F., 6358
Podd'yakov,V.N., 6540
Poeverlein,H., 5598
Pogorelev,A.V., 5239
Poiani,G., 5780
Poincelot,P., 5594
Pollak,P.I., 6181
Pollak,V.L., 5286
Polyak,Yu.Ya., 6391
Pomeranchuk,I.Ya., 5665, 5883
Popescu,C., 5513
Popov,B.E., 6545
Popov,K.V., 6117
Popov,S.N., 5503, 6195
Poquet,E., 6254
Porreca,F., 5250
Porter,G., 6058
Portis,A.M., 6421
Potzschke,M., 6528
Poussot,R., 5955
Powell,B.W., 5618
Powell,C.J., 6100
Powell,W.M., 5788
Powles,J.G., 5287
Pradhan,B.P., 6191
Pramila,G.C., 5829
Prange,R.E., 5692
Pratt,B., 6145
Pratt,P.L., 6483
Predazzi,E., 5697
Preist,T.W., 5857
Prentki,J., 5784
Presnyakov,A.A., 6125
Pressman,J., 6608-12
Preziosi,B., 5653
Prigogine,I., 5205
Prince,E., 6519
Prior,A.C., 6497
Prokoshkin,Yu.D., 5773
Prosen,R.J., 6321
Prowse,D.J., 5930

Ptitsȳna,E.A., 5480
Pugh,E.W., 6275
Purnell,A.D., 5734
Putzeiko,E., 6060
Pyaskovskaya-Fesenkova, E.V., 6589

Quarrington,J.E., 6212
Queisser,H.J., 6170
Querzoli,R., 5726
Qvist,B., 5779

Radicati,L.A., 5675
Rado,G.T., 6393
Raether,H., 6094
Raghavan,R.S., 5829
Raimbault,P., 5410
Rajagopal,E.S., 6440, 644
Rakhman,B.M., 6462
Ramachandran,E.G., 6537
Ramachandran,G., 5751
Ramachandran,V., 6522
Ramakrishna Rao,V., 534
Ramanathan,K.R., 6653
Ramavataram,K., 5941
Ramler,W.J., 5514
Ramos,F., 6512
Ramsey,T.H., Jr, 6499
Ransil,B.J., 6036
Rao,V.S., 6051
Rassmann,G., 6340
Ratcliffe,S., 6171
Rathenau,G.W., 6118, 6298 6546
Razdobarin,G.T., 5481
Razumovskaya,I.V., 6466
Rea,D.G., 6020
Read,F.H., 5934
Rebinder,P.A., 6478
Regel,A.R., 6137
Regge,T., 5191, 5675, 567
Reiderman,N.H., 6350
Reilly,C.A., 6045
Remde,H.F., 6370
Résibois,P., 5205, 5210
Résibois,P., 5210
Resler,E.L., Jr, 5557, 556
Rey,C., 6066
Reynolds,J.M., 5387
Rez,I.S., 6194
Ricamo,R., 5925
Rice,P.L., 5596
Richardson,D.A., 6119
Richman,I., 6209
Riess,F., 5867
Rigamonti,A., 6580
Rimai,L., 6419
Rinehart,E.A., 5603
Rinfret,A.P., 6518
Rîpeanu,S., 6315
Rispoli,B., 5524
Roach,F.E., 6631
Robbins,R.F., 5312
Roberts,P.H., 5552
Robertson,W.D., 5283
Robins,J.L., 6101
Robinson,B.J., 6414
Robinson,D.K., 5756
Robinson,R.J., 6007
Robson,B.A., 5931
Rockmore,R.M., 5392
Rodionov,K.P., 6078
Roev,L.M., 6011
Rogers,J.W., 5293
Rogers,K.C., 5402
Rogers,M.T., 6047
Rohrer,H., 5398
Roitenberg,Ya.N., 5243
Rokotyan,V.E., 5458
Rollin,B.V., 6150

omanenko,E.V., 5324
omanyuk,L.I., 5470
on,A., 5440
onne,B.E., 5728
ose,H.J., 5867
ose-Innes,A.C., 5401
osen,J., 5520
osen,N., 5186
osenberg,B., 6180
osenberg,M., 6316
ösler,U., 6494
oss,D.S., 5117
oss,J.W., 6499
osselet,P., 5716
ossetti,C., 5676
ossow,V.J., 5572
ossteutscher,W., 6528
otenberg,M., 5563
oth,W., 5997
othem,T., 5876
ough,F., 5953
owell,J.M., 6150
owen,J.H., 5577
owley,J.J., 5589
oy,K.K., 5745
ozenberg,L.D., 6578
ubinstein,H., 6326-7
ubinstein,R., 5724
uckenstein,E., 5377
udstam,G., 5854, 5946
uimonte,F.G., 6517
uiz Gonzalvo,J.M., 5242
umsey,N.J., 6633
undle,H.N., 5129
utherglen,J.G., 5772
utkevich,B.H., 5486
yabchikov,L.N., 5378
yabikov,S.V., 5801
yabinin,Yu.N., 6685
yan,D., 6365
ybakov,B.V., 5791
yde,H., 5853
ȳtov,S.M., 6644
ȳtova,N.S., 6152
ȳvkin,S.M., 6140, 6148,
6166, 6177

adler,M.S., 6272
adȳkova,A.I., 5428
agan,C., 5136, 6628
aito,K., 6581
akai,M., 5497
akuma,T., 5666
alam,A., 5656
alandin,G.A., 5780
alant,E.O., 5756
allo,J.S., 6286
alvadori,L., 5501
alvini,G., 5726
alz,F., 5502
amaun, 5951
amelson,H., 6500
amoilov,P.S., 5496
ampson,D.F., 6422
amueli,J., 5410
andage,A., 5127
anders,J.B., 5843
andler,S.R., 5281, 6236
andström,R., 6216
ndulescu,A., 5851
anjeevaiah,B., 5782
anochkin,Yu.V., 5421
app,R.C., 6260
arazin,A., 5410
arles,L.R., 6245
arrouy,J.L., 5984
asaki,T., 6621
ato,H., 6386
ato,K., 5909
atyanarayana,R., 6617

Saunders,A., 5252
Saunders,J.H., 6399
Sauerbrey,G., 5406
Sautter,D., 6135
Savvinykh,S.K., 6068
Sawicki,J., 5693, 5813-14
Saxena,R.P., 5720
Scaramuzzi,F., 5390
Scarfone,L.M., 5657
Schächter,L., 5739
Scharff,M., 5778
Schatzman,E., 5564
Schawlow,A.L., 6246
Scherer,J.R., 5990
Schierholz,H., 6575
Schilling,G.F., 6602
Schinkel,C.J., 6118, 6546
Schlein,P.E., 5832
Schleuning,H.W., 6350
Schlömann,E., 6401-2
Schlüter,A., 5484
Schmeckenbecher,A., 6322
Schmid,H., 6271
Schmitt,A.P., 5955
Schmidt,P.W., 6579
Schmitt,R.W., 6087
Schoen,L.J., 6221
Schoening,F.R.L., 6542
Schön,M., 6080, 6223, 6243
Schork,G., 5934
Schreurs,J.W.H., 6041
Schrieffer,J.R., 5394
Schroeder,D.J., 5974
Schroeder,G.F., 6172
Schroer,B., 5632
Schubert,K., 6528
Schuele,W.J., 6355
Schüller,K., 6338
Schulkin,M., 5333
Schulman,J.H., 5413
Schultz,D.J., 6124
Schultz,G., 5344
Schultz,J., 6446
Schurin,B., 6012
Schwinger,J., 5201
Scott,D., 6564
Scott,G.D., 6553
Scott,H.D., 5796
Sears,G.W., 6501
Sears,W.R., 5546
Secrest,D., 6567
Seeger,D., 6284
Segmüller,A., 6320
Seiidov,Yu.M., 6247
Seiwert,R., 6232
Sekerzh-Zen'kovich,Ya.I.,
5260
Sekine,K., 5634
Selisskii,Ya.P., 6126, 6534
Selleri,F., 5723
Selwood,P.W., 6307
Semendyaev,K.A., 5115
Sen,D., 5339, 5351
Sen Gupta,A.K., 5860
Sen Gupta,R.L., 5745
Sengupta,S., 5810
Sens,J.C., 5742
Seris,G., 5314
Serra,A., 5524
Sessler,A.M., 5235
Sewerynski,M., 5768
Seyer,W.F., 6571
Shafie,I.S., 6184
Shahani,M.G., 5845
Shakhov,V.V., 5478
Shakhovskoi,G.P., 6686
Shamfarov,Ya.L., 5604
Shamro,Z.A., 6197
Shanefield,D., 5368
Shapiro,I., 6013-14
Shapiro,I.I., 5178
Shapiro,I.S., 5663
Sharikadze,D.V., 5538
Sharpton,F.A., 5975
Shaw,H.J., 5588
Shaw,J.E., 6619-20, 6636
Shchukin,E.D., 6471, 6478
Shercliff,J.A., 5571
Sherman,A.E., 5467
Sherwood,R.C., 6382
Shestopalov,V.P., 5585
Shevnin,A.D., 6651
Shichijo,Y., 6371
Shida,S., 6056
Shield,R.T., 6459
Shimodaira,H., 5661
Shiren,N.S., 6072
Shirkov,D.V., 5679
Shiron,N., 6071
Shkilev,A.V., 5429
Shklovsky,I.S., 6630
Shkurskii,B.I., 5517
Shlyamin,É.A., 5948
Shmatov,V.T., 5209
Shmushkevich,I.M., 5883
Shockley,W., 6170
Shoda,K., 5909
Shotov,A.P., 6167
Shpigel',I.S., 5457
Shreider,E.Ya., 5479
Shtrikman,S., 6311
Shull,D.S., Jr, 6299
Shulman,R.G., 6435
Shur,Ya.S., 6295-6, 6533
Shvangiradze,R.R., 6513
Sibley,W.L., 6648
Siddall,G., 6441, 6562
Sidorenko,R.A., 5265
Sidorov,V.A., 5791
Siedentopf,H., 5124
Siegel,K.M., 5145
Siegert,A.J.F., 5204
Sievers,A.J., III, 6413
Silber,L.M., 6350
Silverman,A., 5726
Silverman,J., 6075
Silverstone,C.E., 6483
Silvestrini,G.V., 5765
Sim,A.C., 6143
Simon,G., 6294
Simon,Z., 6033-4, 6053
Simonosohn,G., 5355-6
Sinel'nikov,K.D., 5456,
5487
Singer,S.F., 6645
Singleton,D.G., 5601
Singru,R.M., 5868
Sinnott,K.M., 6005
Sirenko,A.F., 6461
Sirotin,Yu.I., 6490
Sistiaga,J.M., 6530
Sjögren,G., 5554
Skachkov,S.V., 5511
Skanavi,G.I., 6199
Skarsvåg,K., 5725
Skidan,V.V., 5479
Skinner,T.J., 5358
Skrotskii,G.V., 6390
Skurnik,E.Z., 5908
Skvortsov,Yu.V., 5430
Slagg,N., 6574
Slater,W.E., 5832
Šlätis,H., 5933
Šlaus,I., 5928
Slavatinsky,S.A., 5801
Sloanaker,R.M., 5168
Slonczewski,J.C., 6334
Small,R.W.H., 6509
Smirnitsky,V.A., 5748
Smirnov,A.A., 6122
Smirnov,B.I., 6455
Smith,A.W., 6405
Smith,C.A., 5953
Smith,C.S., 6444
Smith,J.E.K., 6666
Smith,D.O., 6317
Smith,F., 6304
Smith,F.T., 5424
Smith,G., 6441
Smith,P., 6517
Smith,P.B., 5506-7
Smith,P.L., 6160
Smith,R.C., 6551
Smith,S.D., 6211
Smith,W.T., Jr, 6061
Smolenskii,G.A., 6195
Smolinski,A., 6283
Smolyankina,T.G., 5511
Smolyanskii,R.E., 5367
Smorodin,Yu.A., 5806
Smulders,P.J.M., 5507
Smulkowski,O., 5615
Snowden,K.U., 6482
Snyder,L.C., 5957
Sobolev,V.V., 5237
Sodha,M.S., 5419
Soergel,V., 5819
Sokolov,A.A., 5687
Sokolov,N.I., 5512
Sokolova,L.V., 5479-80
Solbrig,A.W., Jr, 5919
Šoln,J., 5630
Solomon,I., 6248
Solov'eva,Z.I., 5944
Solov'eva,Z.Z., 5945
Solymar,L., 5445
Somin,B.Kh., 6487
Soohoo,R.F., 6397
Sorensen,N.R., 5326
Soule,D.E., 6254
Spain,R.J., 6327
Spar,J., 6597
Sparks,M., 6375
Spîrchez,M., 5758, 5799
Spitzer,L., Jr, 5545
Spitzer,R., 5642
Spivak,P.E., 5900
Spicer,B.M., 5890-1
Spurr,R.T., 5320
Squires,R.E., 5138
Sreekantan,B.V., 5805
Sretenskii,L.N., 5260
Srinivasa Rao,M.V., 5805
Srivastava,S.N., 5241
Stacey,F.D., 6277
Stafeev,V.I., 6168
Stafford,G.H., 5922
Stalinski,B., 6437
Stanchi,L., 5411
Stanghellini,A., 5759, 5763
Stapleton,H.J., 6420
Stark,M., 5707
Startseva,I.E., 6295
Statz,H., 6419
Stavitskaya,T.S., 6161
Steele,W.A., 5374
Ştefănescu,S.S., 5533
Stein,G., 6577
Stein,W., 5152
Steinberg,P.H., 5832
Stekol'nikov,I.S., 5429
Stemme,O., 6276
Stepanov,B.M., 5623
Stephen,M.J., 6043
Stephens,D.R., 6206
Stephenson,C.B., 5165
Stepina,N.É., 6487
Stern,E., 5587
Stevenson,F., 6123
Stevenson,M.L., 5727
Stewart,A.L., 5961
Stewart,D.T., 5409
Stewart,W.C., 6688
Stewartson,K., 5558
Stickler,J.J., 6381
Stil'bans,L.S., 6161
Stipčić,N., 5928
Stiubei,P., 5425
Stockendal,R., 5864, 5871
Stocker,H.J., 6169
Stoker,P.H., 5607, 5765
Stolov,A.L., 5436
Stolov,A.M., 5477-8
Stolz,E., 6528
Storms,E.K., 6515
Stoudenheimer,R.G., 6237
Strauss,W., 5577
Streater,R.F., 5888
Strelkov,V.S., 5462
Strel'tsov,N.S., 5477
Strokan,N.B., 6166
Strömberg,L.G., 5863
Stroud,P.T., 6493
Stueckelberg,E.C.G., 519
Sturr,J.F., 6671
Sugano,S., 5992
Suita,T., 5437
Sulich,M., 6285
Sullivan,D.L., 6326
Sultan,F.S.A., 6184
Summers-Gill,R.G., 5820
Sundaram,S., 6000
Sutula,V.D., 5627
Suzuki,K., 6371
Svanheden,Å., 5854
Swalen,J.D., 6045
Swan,J.B., 6101
Swann,C.P., 5876
Swartz,D.B., 5590
Swiatkowski,W., 5755
Swierszcewski,S., 5796
Swoboda,T.J., 6272, 6374
Sykes,M.F., 6263-4
Sȳchev,Yu.D., 5536
Sȳsuev,Yu.A., 6456
Szondy,T., 6027
Szymanski,J., 5646

Tabellini,G.L., 5119
Taffara,L., 5423
Tagliabue,F., 5889
Tai Tsun Wu, 5223
Takahashi,Y., 5661
Takayanagi,S., 6492
Tako,T., 5576
Talbot,J.H., 6557
Tanaka,S., 6581
Tanaka,Y., 6021, 6586
Tanenbaum,M., 6156
Tang Syao-Wei, 5773
Tangherlini,F.R., 5193
Tanner,L.E., 6452
Tanner,N.W., 5838
Tarkhin,D.V., 6166
Tarkhova,T.N., 6507
Tartaglione,E., 5267
Taskoprulu,N.S., 5277
Tassie,L.J., 5824
Tatsumi,T., 5553
Tatu,V., 5296
Tayler,R.J., 5565
Taylor,B.N., 5400
Taylor,E.H., 6061
Taylor,G.M., 5401
Taylor,H.W., 5704
Taylor,R.C., 6186
Taylor,T.T., 5528
Teale,R.W., 6403-4
Telegdi,V.L., 5742
Tenner,A.G.C., 5621

ten Seldam,C.A., 5294
Teramoto,I., 6492
Terenin,A., 6060
Terenin,A.N., 5491
Terlekskii,Yu.P., 5208
Terrien,J., 5249
Terzi,N., 6067
Teutonico,L.J., 6443
Teutsch,H., 5954
Thaxter,J.B., 6381
Thayer,G.D., 5597
Theile,R., 5125
Theisen,J.F., 6594
Thellung,A., 5197
Thieberger,P., 5855
Thirring,W., 5747
Thomas,H., 6330
Thomas,J.A., 5601
Thomas,M.A., 6018
Thomas,R.N., 5154, 5968
Thompson,A.R., 5167, 6641
Thompson,M.N., 5890-1
Thompson,T.J., 5950
Thompson,W.B., 5446
Thomsen,J.S., 5383
Thomson,J.O., 5390
Thornton,E., 5476
Thorp,J.S., 6422
Thresher,J.J., 5922
Thyagarajan,G., 6000
Ticho,H.K., 5788
Tiemeyer,J.C., 5508
Tietz,T., 5962, 5978
Tikhinskii,G.F., 5378
Timis,P., 5954
Timofeev,A.N., 6113
Tims,D.W., 5263
Tinkham,M., 6413
Ţintă,F., 5412, 5581
Tiomno,J., 5775
Tischler,O., 6172
Ţiţeica,S., 5750
Tochilin,E., 5736
Tohei,T., 5909
Toitot,M., 6555
Tolk,N.H., 5737
Toll,J., 5196
Tolmachev,V.V., 5226-8
Tolman,E.M., 6543
Tolok,V.T., 5456, 5487
Tolstoi,N.A., 6233
Tomaš,P., 5928
Tomasini,A., 5689
Tomasini,G., 5916-17
Tomkins,F.S., 5971
Tomozawa,Y., 5699
Tomozei,C., 5365
Tonin,M., 5674
Torizuka,Y., 6388
Toth,T., 5513
Ţoţia,H., 5739
Towle,J.H., 5734, 5940
Toyoda,T., 5643
Tradowsky,K., 5406
Trakhtenberg,I.Sh., 6113
Tran Thanh Van, J., 5789
Travers,S., 6509
Treacy,P.B., 5935
Trees,R.E., 5977
Treloar,L.R.G., 6450
Treucker,F., 5344
Treves,D., 6299, 6303
Tripathi,B.B., 6076
Trischka,J.W., 5996
Tröim,J., 6614
Troost,A., 6458
Trossi,L., 5715
Trost,W., 5867
True,W.W., 5837
Tsarevskii,B.V., 5265
Tsomaya,K.P., 6513
Tsujiuchi,J., 5338
Tsun Wu Tai, 5223
Tsuya,N., 6371
Tsuzuki,Y., 5800
Tsȳbina,N.V.T., 5248
Tucker,E.B., 6071, 6073
Tulinova,N.I., 5521
Turchinetz,W.E., 5892
Turbadar,T., 6204
Turnbull,D., 5272, 6550
Turov,E.A., 6121
Tveten,L.H., 6622
Tyablikov,S.V., 6392
Tzu,H.Y., 5679

Ueda,H., 6056
Uehara,Y., 6226
Uhlenbeck,G.E., 5203
Ullman,F.G., 6182
Ulmanis,U., 5701
Ulrich,P.B., 5494
Umezawa,H., 5625, 5633
Umezawa,M., 5812
Unger,K., 6244
Unruh,W., 6260
Unz,H., 5599
Uretsky,J.L., 5757
Ursu,I., 5297, 6572
Usova,I.N., 5708

Vagner,S.D., 5431
Vail,C.R., 6688
Vainshtein,É.E., 6218
Vainshtein,L.A., 5583-4
Vakhovskaya,M.R., 6468
Vakulov,P.V., 5797
Valatin,J.G., 5217
Valin,J., 5614
Valladas,G., 5770
Van Biesbroeck,G., 5139
Van Bladel,J., 5510
Van de Graaff,R.J., 5509
Van de Walle,R., 5698
van der Kaa,J.M., 6129
van der Raay,H.B., 5724
van Haeringen,W., 5636-7
van Herk,G., 5121
Van Hove,L., 5233
Van Rossum,L., 5770
van Vleck,J.H., 6389
van Woerkom,A.J.J., 5121
Vanyukov,K.P., 5428
Vardya,M.S., 6050
Văsaru,G., 6572
Vashakidze,I.Sh., 5818, 5856
Vasil'ev,A.M., 6415
Vasiliu,G., 6282
Vaughan-Williams,R.W., 5443
Vavilin,E.I., 5431
Vavilov,V.S., 6152
Venkatasubramanian,V.S., 5498
Ventateswarlu,P., 6617
Verdini,L., 6448
Vereshchagin,L.F., 6685
Vergunas,F.I., 6192
Verhaar,B.J., 5816
Verniani,F., 6626
Vernotte,P., 5314
Vernov,S.N., 5797
Vestine,E.H., 6598, 6627 6648
Vidal,J.M., 5278
Videira,A.L.L., 5775
Vilesov,F.I., 5491
Vinci,F., 5925
Vineyard,G.H., 6120
Vinogradov,V.S., 6190
Viola,C., 5423
Visconti,A., 5625
Vishnyakov,Ya.D., 6106
Visser,M.P., 6514
Vitale,B., 5717-18
Vlasov,N.A., 5791
Vogt,O., 6253
Vogler,L.E., 5596
Vohra,K.G., 5848
Voigt,J., 6176
Volet,C., 5298
Volger,J., 6188
Volǩov,Ya.F., 5456
v. Békésy,G., 6663
v. Weyssenhoff,H., 6576
Vorob'ev,G.A., 5427
Vovchenko,V.G., 5755

Wade,G., 6408
Wagner,M., 6675
Wahlström,I., 5895
Waibel,E., 5807
Waissenberg,A.O., 5748
Waldner,F., 5780
Walecka,J.D., 5835
Walker,J.K., 5772
Walker,L.R., 6262, 6353, 6363
Walker,T.G., 5894
Walker,W.D., 5741
Wallace,L., 6639
Wallenstein,M.B., 5418
Wanders,G., 5668
Wang Yung, 5767
Wanic,A., 5730
Wapstra,A.H., 5495, 5923
Warburton,E.K., 5837
Ward,J.C., 5656
Ward,R., 6376
Warren,B.E., 6107, 6565
Warwick,J.W., 5177
Wassef,E.G.T., 6679
Watabe, M., 6102
Watanabe,A., 6405
Watanabe,H., 6046
Watkins,T.B., 6138
Watson,K.M., 5442
Watson,R.E., 6269
Watt,L.A.K., 6281
Weart,H.W., 5380
Weber,A., 6019
Weber,M.J., 6419
Weber,R.L., 5184
Webster,D.L., 5189
Webster,J.C., 6661
Wegener,H.H.F., 5830
Weger,M., 6421
Weidling,T., 5863
Weiner,M., 5617
Weiss,M.T., 6407
Weitzel,D.H., 5312
Weller,A., 6059
Wells,D.O., 5612
Welsh,H.L., 6018
Wentorf,R.H., Jr, 6498
Wentzel,G., 5397
Wernick,J.H., 5399, 6382
Wertheim,G.K., 6249, 6262
Wess,J., 5631
West,F.G., 6314, 6328
West,R.G., 6373
Westwood,A.R.C., 6474
Whan,R.E., 6228
Wheeler,H.A., 5602
Whipple,F.L., 6643
White,D.R., 5548
White,M.W., 5183
White,P.G., 5781
Whitmore, D.H., 6163
Whitney,C.A., 6602
Whitten,R.C., 5858
Whyte,G.N., 5704
Wich,H., 6340
Wickersheim,K.A., 6208
Widing,K.G., 5153
Wiedenbeck,M.L., 5866
Wieder,I., 6245
Wiktor,S., 5766
Wilcox,C.F., Jr, 6023
Wilhelmi,Z., 5912
Wilkinson,M.K., 6347-8
Williams,D., 6436
Williams,H.J., 6382
Williams,N., 6212
Williams,W.J., 6590
Williamson,R.M., 5907
Wilson,C.B., 6099
Wilson,C.O., Jr, 6013-14
Wilson,N., 6450
Wilson,R.H., 6279
Wilson,R.J., 5476
Wilson,W.D., 5329
Winslow,D.K., 5588
Winterberg,F., 5187
Wisseman,W.R., 5907
Witteveld,H., 5621
Wohlfarth,E.P., 6311
Wolf,H.C., 6231
Wolf,P., 6323
Wolf,W.P., 6365, 6423
Wollan,E.O., 6347-8
Woltjer,L., 5566
Wood,C., 6172
Wood,W.A., 6476
Woolfson,M.M., 5130
Wong,E.Y., 6209
Woyk(Chvojkova),E., 662
Wright,C.V., 6003
Wright,I.F., 5892
Wright,K.H.R., 6564
Wright,M.R., 6058
Wu Tai Tsun, 5223
Wucher,J., 6357
Wyard,S.J., 6551
Wycklendt,D.A., 6290
Wycliffe,H., 5308

Xuong,N.H., 5727

Yagn,Yu.I., 6467
Yakovlev,E.I., 6267
Yamagata,T., 5518, 5702
Yamaguchi,J., 6165
Yamaguchi,T., 6357
Yamaguchi,Y., 5784
Yamamoto,K., 5647
Yamanaka,C., 5437
Yamashita,J., 6133
Yamazaki,K., 5694
Yang,C.N., 5224
Yates,M.J.L., 5841
Yavlinskii,N.A., 5462
Yeadon,R.E., 6119
Yekutieli,G., 5903
Yermolov,P.F., 5766
Yi Chen Yung, 5786
Yntema,J.L., 5514
Yosida,K., 6268
Young,J.E., 5885
Yung Wang, 5767
Yung Yi Chen, 5786
Yursik,I., 5852

Zagury,N., 5775
Zahlan,A.B., 6090
Zaidel',A.N., 5479-81
Zaidel',R.M., 5115
Zakrzewski,J., 5782
Zaleski,C.P., 5955
Zasimchuk,I.K., 6110
Zaslavskaya,I.G., 6089
Zav'yalov,O.I., 5684
Żelazny,R., 5639
Zel'dovich,M.P., 5519
Zhdan,A.G., 5490
Zhekulin,L., 6616
Zheludev,I.S., 6194
Zherebtsova,N.D., 5369
Zhigulev,V.N., 5444, 665
Zhuravlev,G.V., 5988
Zichichi,A., 5742
Zijlstra,H., 6342
Ziomek,J.S., 6016
Zirin,H., 5155
Zirker,J.B., 5968
Zolotavin,A.V., 5874
Zorzoli,G.B., 5732
Zubarev,D.N., 5212
Zückler,K., 5435
Zwerdling,S., 6203

Physics Abstracts

welcomes applications from physicists willing to offer their services as

Abstractors

Expert knowledge of some branch of modern physics is required (of research standard) and it is desirable to have a reading knowledge of at least one foreign language, particularly

Russian or German

The articles and books abstracted can be retained by the abstractors, and fees are paid for all abstracts published (foreign articles at a higher rate).

Apply to
Science Abstracts
The Institution of Electrical Engineers
Savoy Place, London, W.C.2

The Institute of Physics and The Physical Society

★

The Institute of Physics and The Physical Society were amalgamated in 1960, the objects of the new body being the advancement and dissemination of a knowledge of physics, and the elevation of the profession of physics.

There are four grades of full membership:

(a) Fellow of The Institute of Physics

(b) Associate of The Institute of Physics

(c) Graduate of The Institute of Physics

> *The above are all professional grades, members of these grades being automatically also Fellows of The Physical Society.*

(d) Fellow of The Physical Society

Full details of membership, including the non-member grades of Student and Subscriber, may be obtained from
The Institute of Physics and The Physical Society
47 Belgrave Square, London S.W.1

Science Abstracts

is edited and published monthly by
THE INSTITUTION OF ELECTRICAL ENGINEERS
in association with
The Institute of Physics and The Physical Society
The American Physical Society
The American Institute of Electrical Engineers
in two sections:

Section A:

Physics Abstracts

Section B:

Electrical Engineering Abstracts

Science Abstracts
is devoted solely to the recording, summarizing and indexing of original publications on physical and electrical science and practice throughout the world, and has been in continuous publication for 63 years.

Physics Abstracts
is a co-operating member of the I.C.S.U. Abstracting Board (International Council of Scientific Unions).

Committee of Management 1960-1961

THE INSTITUTION OF ELECTRICAL ENGINEERS
The President (*ex officio*)
L. Hartshorn, D.Sc., M.I.E.E.
R. W. Sillars, B.A., D.Phil., M.I.E.E.
R. L. Smith-Rose, C.B.E., D.Sc., Ph.D., M.I.E.E.
H. G. Taylor, D.Sc.(Eng.), M.I.E.E.

THE INSTITUTE OF PHYSICS AND
THE PHYSICAL SOCIETY
J. H. Awbery, M.A., B.Sc. (*Chairman*)
W. R. S. Garton, B.Sc., Ph.D.
D. Roaf, M.A., D.Phil.
Miss A. C. Stickland, M.Sc., Ph.D
L. R. G. Treloar, B Sc., Ph.D., D.Sc., F.Inst.P.

THE ROYAL SOCIETY
W. C. Price, Sc.D., F.R.S.

THE CENTRAL ELECTRICITY GENERATING BOARD
H. W. Gatehouse, A.M.I.E.E.

OBSERVER FOR THE AMERICAN PHYSICAL SOCIETY
T. H. Osgood, Ph.D.

Editorial

Editor
B. M. Crowther, M.A., Ph.D., F.Inst.P.
Section Editor (Physics)
H. Jenkins, B.Sc.. A.Inst.P.
Section Editor (Electrical Engineering)
L. MacQuisten Wallace, B.Sc., A.M.I.E.E., A.M.I.E.(Aust.)
Assistant Editors (Physics)
J. R. Day, B.Sc.
N. R. Fowler, A.R.C.S., D.I.C., F.Inst.P.
A. M. Lever, M.A.
V. K. Royce, B.Sc. A.R.C.S.
A. Tybulewicz, B.Sc.
T. B. Wright, B.Sc., A.R.C.S.
Assistant Editor (Electrical Engineering)
J. J. Mulroy, B.Sc.

Annual Subscriptions

Science Abstracts is published in two sections, available separately:

Section A, *Physics Abstracts*	£10 0 0
Section B, *Electrical Engineering Abstracts*	£7 0 0
Both sections	£16 0 0

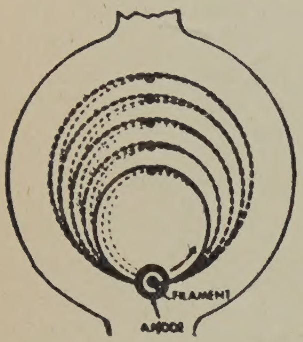
THE INSTITUTION OF ELECTRICAL ENGINEERS
Savoy Place, London, W.C.2 *Telephone:* COVent Garden 1871

WELCH e/m APPARATUS

Bainbridge Design

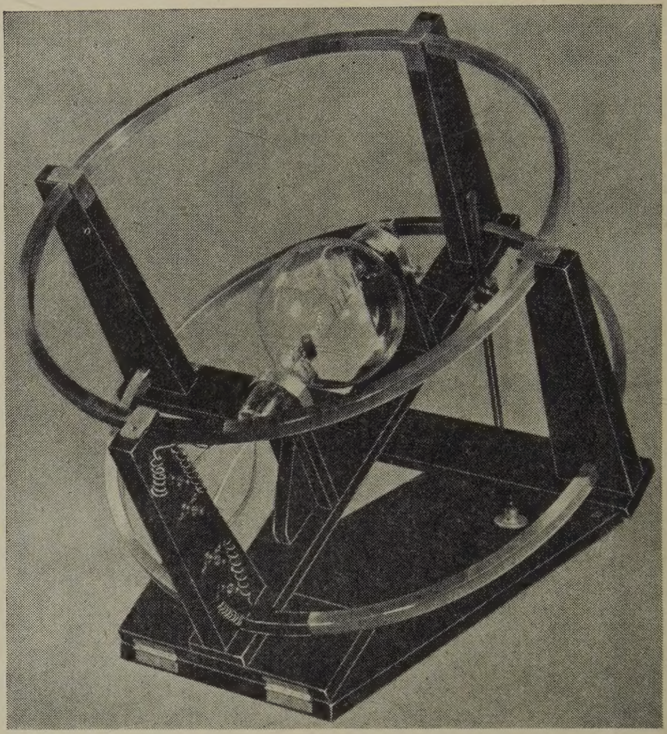
For Measuring The Ratio Of The Charge To The Mass Of An Electron

Tested Accuracy within 2 % of accepted value of e/m



Stream of electrons, made visible by mercury vapor in the tube, is bent to desired radius of path by a magnetic field.

Acclaimed By Teachers As The Most Effective Method For Student Use



No. 623 and No. 623A

One of the most fascinating demonstrations of physics is the controlled bending of a stream of high-speed electrons in a magnetic field. The actual measurement, by students, of the ratio of the charge on the electron to its equally minute mass imparts a stimulating sense of achievement.

The Welch e/m apparatus has been perfected to the point where it is possible for this fundamentally important measurement to be carried out with good accuracy even by students who have not progressed beyond the fundamentals of electricity.

It consists essentially of a specially designed vacuum tube supported at the center by a pair of large Helmholtz coils which are 66 cm in diameter. They are large enough to give a uniform magnetic field and are supported such that they can be adjusted to the dip angle so that their field will not be distorted by the earth's field. A graduated scale indicates the angle of tilt.

No. 623. e/m VACUUM TUBE. Designed and fabricated for the experiment, as described, and including detailed instructions, each, $85.00.

No. 623A. HELMHOLTZ COILS. Consisting of two cords 66 cm in diameter, supported by a hinged secondary base with dip-angle scale, safety clutch, and brackets for mounting the e/m Vacuum Tube at the center, each, $195.00.

WRITE FOR COMPLETE CIRCULAR

THE WELCH SCIENTIFIC COMPANY
ESTABLISHED 1880
1515 Sedgwick Street, Dept. PA   Chicago 10, Illinois   U. S. A.
Manufacturers of Scientific Instruments and Laboratory Apparatus

PRINTED BY UNWIN BROTHERS LIMITED, WOKING AND LONDON